Electricity Costing and Pricing Study

Volume VI

Alternative Objectives for Pricing

October, 1976

ELECTRICITY COSTING AND PRICING STUDY

VOLUME VI
ALTERNATIVE OBJECTIVES FOR PRICING

Ontario Hydro
October 1976

Table of Contents

I. INTRODUCTION

A. HISTORICAL PERSPECTIVE

The primary purpose of any pricing-system and rate structure is to recover total operating-costs. The earliest pricing-structures for electricity accomplished this through various approaches. Because of the lack of acceptable meters, the methodology involved dividing total utility costs by what was considered to be the relevant variable, producing monthly flat (unmetered) rates charged by light, by customer, by room or by horsepower of connected motor loads. Such flat rates are still suitable where both load and hours of use can be established within reasonably accurate limits, or where use is insufficient to warrant metering: for example, street lights controlled by photo-electric cells, telephone booths, etc. Otherwise flat rates are no longer considered an appropriate method for pricing electricity, since they neither track costs nor allow for differences in demand or use.

Accurate measurement of kilowatt-hour consumption became possible with the development of the induction-type watt-hour meter. With the later introduction of kilowatt demand meters, it became possible to measure the differential between the sum of customers' non-coincident demands and total system demand. Thus a problem of cost allocation developed. There were those who felt that kilowatt-hours were a more appropriate measure of costs, because the total kilowatt-hours all customers used, plus losses, equalled the total kilowatt-hours the system generated. Moreover, kilowatt-hours were a measure of output of the commodity purchased. Others held that the rate of use of kilowatt-hours, or kilowatts, more accurately reflected system costs, in that the fixed costs of generation (which was primarily hydraulic) represented the largest share of the total costs of operation. Thus demand or kilowatt charges were necessary to reflect the costs associated with different rates of use. Clearly, if there were no costs associated with differing demands for kilowatt-hours throughout the day or the year, or conversely if there were little or no cost associated with storing kilowatt-hours, there would be no need for a demand (or rate-of-use) charge. In fact if it were technically and administratively feasible to have a sufficient number of rates to track generation costs as they vary through time, a demand charge would not be necessary, and the associated problems of cost allocation would disappear.

While use of demand measurements coincident with system peak may be a technically correct solution for allocating capacity costs, its use in a rate structure could create load instabilities or shifting peaks, as customers attempt to avoid incurring peak capacity charges.

In the 1880s, two British engineers developed rate forms that recognized both size of load and energy use. Hopkinson developed a two-part rate consisting of separate charges for demand and energy, thus recognizing load factor. Wright's rate consisted of energy blocks with decreasing prices for succeeding blocks, and in which the size of energy blocks increased with size of load. The effect was to charge for both demand and energy, again recognizing load factor.

Until 1951, Ontario Hydro's bulk-power charges were based only on demand, and were applied to monthly non-coincident peak demands for power. This method was followed because the costs of generating power in the hydraulic system did not fluctuate materially with the amount of energy supplied.

With the introduction of peaking hydraulic and steam generating-plants about mid-century, a change in the rate structure was required to take into account added fuel costs and capacity operating at relatively low load factor. In 1951, an energy charge set at 35 per cent of the power supply function's cost was introduced.[1] This was raised to 50 per cent in 1957.

In 1966, when the present power-costing system was introduced, the energy rate was set at 2.75 mills per kilowatt-hour. This was less than the fuel cost of the Lakeview Generating Station, which was the marginal plant at the time (3.2 mills per kilowatt-hour). The difference recognized the existence of historically less costly sources of energy. The demand rate was based on the cost of providing all the common functions after deducting the amount recovered through the energy rate. In 1966, the annual demand rate was $23.74 per kilowatt.

During an era when natural resources required developing and electrification of the province was important for an expanding economy, economies of scale were inherent in the electrical utility industry. Essentially, for the residential customer the burden of historical investment was distributed on a volume basis by a block energy-rate structure. The end rate, reflecting the benefits of scale, was below the average unit costs for electricity. Thus in order to meet the revenue requirement, the front-end block rates were made higher, to reflect costs which were not a function of use or rate of use of kilowatt-hours.

B. ALTERNATIVE PRICING-OBJECTIVES

While still meeting the financial objective of recovering costs, rates can be designed to attain several other pricing-objectives, such as economic efficiency, fairness, redistribution of wealth or social-welfare, conservation, and environmental protection.

The recommended pricing-objective of economic efficiency is studied in considerable detail in Volume V, along with objectives of fairness, which are not unique to any particular pricing-methodology. Other alternative pricing-objectives and their corresponding rate structures are described and analysed in this volume. All the pricing-objectives were examined in the context of the corporate objective and the prevailing socio-economic conditions. Their advantages and disadvantages were developed, and the reasons for rejection stated.

Section II examines the objectives of the traditional fully distributed embedded-average-cost pricing-system, including those aspects of fairness usually associated with this type of system. For an average-cost pricing-system, 'fairness' means a fair allocation of overhead, joint, and of fixed costs, and the benefits or burdens of historical investment, to all customers. Additionally, this involves averaging historical plant, averaging variable costs of generation mix at any given time, and averaging the costs of output over time.

Included as appendices to this section are

1. A paper describing the fully distributed average-cost pricing-system that now forms the basis for pricing electricity within Ontario.
2. A background paper examining a number of methods of apportioning total common costs proposed over the years.

The third section considers the objective of pricing electricity for energy conservation and its effect on rate structures. Pricing electricity to achieve significantly dampened growth rates or even zero electricity growth suggests inverted rates. Inverted rates may be defined as progressively higher block unit prices for electricity as more kilowatt-hours are used. Conservation groups would be the main proponents of a rate structure designed to retard the depletion of scarce natural resources. The

[1] This is the cost of generation, purchased power and frequency changers.

appendix to this section outlines the policy of inverted rates carried out in a Japanese utility (CHUBU).

Use of the utility rate structure to strive for social-welfare objectives is the subject of Section IV. Consumer groups and various regulatory bodies have advocated various rate-based schemes for redistributing wealth as solutions to social problems arising from recent increases in the price of electricity. Three redistributive programs are discussed in this section: lifeline rates, energy stamps, and an energy tax credit. Currently in vogue with proponents of such social-welfare pricing-objectives are lifeline rates. A lifeline rate may be defined as a low uniform charge for the first several hundred kilowatt-hours each residential customer uses.

The fifth and last section reviews the pricing-objective of environmental protection. Steps toward this objective would include introducing a shadow price equal to the marginal net damage from producing electricity. The shadow price would then be added to the utility's marginal private cost to arrive at a social price for electricity. This would drive prices for electricity upwards, slowing load growth and reducing the projected effect on the environment of producing electricity, since customers would face the full social cost consequences of their decisions about use.

II. TRADITIONAL FULLY DISTRIBUTED EMBEDDED-AVERAGE-COST PRICING

This section of the volume will define and analyse average-cost pricing, and present the arguments for and against applying fully distributed average costs to rate-making.

A. EMBEDDED-AVERAGE-COST PRICING OR FULLY-DISTRIBUTED-COST PRICING (FDC) DEFINED

A fully-distributed-cost pricing-system results from a cost allocation procedure in which average costs are determined for each class of customers, based on the total embedded costs incurred by the power system, independent of how such costs would increase or decrease if output were increased or decreased.

While apportioning these costs among different customer classes is not an easy task, mainly due to the presence of many common or joint costs, the most frequently used division is a threefold one: (1) demand or capacity costs; (2) energy or output costs; and (3) customer costs.[2]

The procedure for distributing total costs would generally be as follows:

1. Distribute total annual costs among the various classes of service;
2. Distribute the costs of each class among service characteristics: that is, customer, kilowatt-hour (energy) or kilowatt (demand).

For Ontario Hydro. demand and energy costs are allocated to the municipalities and the Power District. (Customer-related costs at the bulk-power level are insignificant). Each municipality and the Power District must recover these costs of the bulk-power system from the different customer classes. In practice, the bulk-power costs represent variable costs for the municipal utility, which are added to the variable cost of its retail-distribution system.

A description of Ontario Hydro's present pricing process is found in Appendix I.

Apportioning demand costs has traditionally proved troublesome. Appendix II examines this area of concern more closely. At present, Ontario Hydro's demand cost allocation is based on the customers' non-coincident demands.

B. STATED ARGUMENTS FOR FULLY DISTRIBUTED AVERAGE-COST PRICING

It is claimed that rate-making is an art rather than a science, requiring the experience and reasoned judgement of those familiar with the industry and its costs, load patterns, customers, etc. However, certain general principles and arguments that are used in support of fully distributed average-cost pricing may be summarized under the following five headings:

1. Fairness,
2. Accountability,
3. Administrative Expense,
4. Flexibility and Cost Justification, and
5. Conservation.

1. Fairness

Any pricing-system a public utility employs must be fair. With a fully distributed pricing-system (FDC) employing average costs. the fixed, overhead and joint-cost portions of the revenue requirement are allocated 'fairly' among the various customer classes based on the relative consumption characteristics of the classes and thus on their adjudged responsibility for incurring these costs. The resulting revenue requirement of the class is then distributed among the customers in a similar manner.

2. Accountability

There is a high degree of accountability, since average-cost pricing is based directly on the projected actual book costs over the time-frame in which the rates are to apply. The revenue requirement will be met exactly; and hence, all other things being equal, there will be no surplus revenues. This accountability provides a standard for evaluating past allocations of costs to the various customer classes, and therefore a reference point for future decisions. When a particular class of customers does not produce enough revenue to cover its allocated costs, that is a sign that that class may be enjoying a subsidy.

3. Administrative Expense

A fully distributed average-cost pricing-system is less expensive and more attractive administratively than other costing and pricing-techniques. With costs averaged over time and output, the system requires a minimum of administrative cost (metering and load data). The rate structures, in turn, are relatively straightforward.

4. Flexibility and Cost Justification

A fully distributed pricing-system has the flexibility to meet the revenue requirement yet still remain equitable. Within the limits of practicality, there is no undue discrimination between classes. Where the quantity and rate of use are the same, the total charge to the customer is the same, unless identifiable cost differences in the conditions of service justify a difference. Ideally, at the same time, each customer shares proportionately in the historical benefits of investment.

Every pricing-system which generates only sufficient revenue to meet the revenue requirement based on historical costs does in fact provide the historical benefits of investment to all customers. However, fully distributed average-cost pricing attempts to return the benefits to each individual customer, as much as is possible, on the basis of that customer's consumption.

5. Conservation

It is argued that FDC pricing is consistent with conservation principles.

> *Proper conservation should recognize the full economic costs of supplying service today. It should not require today's consumers to subsidize the costs of providing service in the future. With costs increasing rapidly over time, it is appropriate for rate regulation to consider cost information that goes beyond the traditional historical test year. Because the rates being determined will apply over the next year or two, it is appropriate to consider forecasts of the costs that will be incurred and recorded on the books of account. These forecasts constitute the best estimate of what the costs actually will be in the period during which the rates will be charged.*[3]

C. THE CASE AGAINST FULLY DISTRIBUTED AVERAGE-COST PRICING

This section will examine several leading criticisms of fully distributed average-cost pricing.

---

[2]Demand. energy, customer, common and joint costs are discussed in Volumes II, III, V and VII.

[3]Dr William Melody, Testimony for California Manufacturers Association before the Public Utilities Commission of the State of California. February 18, 1975, pp 30-31

1. The Fairness Case

Consider the claim that fully distributed average-cost pricing is fair because customers receive the benefits of historical investment decisions in a period of increasing costs. While this statement is true, it is also true for other pricing-methodologies.

As long as the revenue requirement is based on historical accounting-costs, it follows by definition that the customers will receive the benefits of historical investment. If, for example, the revenue requirement were based on the current-value cost of reproducing the plant in place, then the benefits of historical investment would accrue to the utility, even under a system of average-cost pricing.

It should be noted further that where unit costs are decreasing and the revenue requirement is based on historical dollars, the customers of the utility must bear the *burden* of the historical investment decisions. Again, this situation applies regardless of the rate structure employed, FDC or marginal cost pricing.[4]

It may be concluded, then, that even with marginal-cost pricing and the objective of efficiency, customers will receive the benefits of historical investment decisions because of the constraints of revenue requirements.[5]
It simply becomes a question of how historical benefits are apportioned to the customers.

2. The Use of Averages

There are three main types of averaging implicitly employed in the FDC approach:

1. *Historical Averaging*. Historical accounting-costs using dollars of different vintage are used to develop rates. For example, the costs associated with older plant through cost tracking of the depreciation accounts are averaged in with current costs of new plant. This is an averaging process that disregards the vintage of the dollars used to buy the plant.
2. *Plant (or Fixed) Cost and Energy (or Variable) Cost Averaging*. This process averages the technology mix of all generating-plant to determine the demand (kilowatt) charge. On the energy (kWh) charge, the process represents an average of the variable costs associated with each type of generation (hydraulic, nuclear and thermal).
3. *Cost Averaging Through Time*. The higher costs of providing electricity in the peak period (by season and by day) are averaged in with the lower costs of providing electricity in the off-peak periods.

The use of averages will generally understate the cost the utility incurs in supplying additional electricity (in periods, that is, of inflation or diseconomies). Since the demand for electricity is sensitive to price, this leads to overbuilding plant to meet the excess demand. Time averaging results in plant mixes that are less than optimal, and excessive demand.

3. The Wasteful Use of Electricity

In a changing world, average embedded accounting-costs will not provide a reliable measure of what will happen to future costs with changes in output. As such, any form of fully distributed average costing will not provide the kind of information needed if rates are to reflect the relevant marginal costs of production.

Costs incurred in the past have little significance in pricing-decisions for the future, because of substantial changes in operating-conditions, facilities, and patterns of use in recent years. However, if embedded costs are adjusted to account for inflation and technological change, they may be used as an estimator for prospective costs, if cost-justified. Analyses of historical accounts generally do not disclose the costs needed for informed pricing-decisions. This is due to several factors. They are historical or 'sunk' costs, rather than the marginal costs pertinent for pricing-decisions on future courses of action. They do not reflect the significance of increasing costs. And they do not reveal costs on the basis of cost-causing responsibility.

In a period of increasing costs, prices based on fully distributed average costs lead to wasteful use of electricity. Waste refers to additional consumption which would not occur if prices tracked the costs associated with an increase or decrease of output. The point can be illustrated with a hypothetical example:

Consider a residential end rate, based on historical average costs, of 1.5 cents per kilowatt-hour. Assume further that the current cost to the utility of producing an additional kilowatt-hour is two cents.

In this example the price that the customers face (that is, the price they respond to) is 1.5 cents per kilowatt-hour; but the cost the hypothetical utility incurs in meeting additional customers' demands - the cost of input resources, such as capital and coal - is two cents per kilowatt-hour for all further kilowatt-hours.

This means that the customer does not see the full cost consequences of using more kilowatt-hours. And as the demand studies indicate, customers respond to the prices they face.

As the customer buys more electricity in response to the 1.5 cents per kilowatt-hour, the producing electrical utility needs more plant and more primary energy to produce that additional electricity. The cost of the additional plant and energy is greater than the price the customer faces. The load growth is greater than it would otherwise have been if the price of electricity had reflected the actual cost of additional production, namely two cents per kilowatt-hour.

Because of the more rapid growth, the greater the demand will be; and the utility's revenue requirement will increase to compensate for the added costs of production, which means its prices will increase. However, owing to the utility's embedded-average-cost pricing, the resulting prices will still be below the cost of additional production. The customer, in turn, again responds to these increased prices, which are still below the cost of production. This leads to inefficient and wasteful use of society's resources. One way the utility can break out of this circle is to base its rates on the marginal cost of production. If (as in the example) the utility is about to incur costs on behalf of its customers of two cents per kilowatt-hour, then ideally that is the price which the customer ought to face, and to which he should respond.

FDC has not treated the marginal cost of producing electricity as a pricing-instrument, and thus sidesteps the question of economic efficiency. Insofar as the demand for electricity is sensitive to price, underpricing marginal use at average costs will encourage unnecessary growth in capacity requirements.

4. Administrative and Technical Feasibility

It is argued that FDC is administratively more practical than

[4]Appendix VI of Volume VIII demonstrates the relationship between the basis for determining the revenue requirement and the resulting benefits (burden) of historical investment which result from inflation (deflation), technological restraints and economics or diseconomics of scale

[5]See Volume V, Appendix III for a discussion of fairness and efficiency.

marginal cost pricing. Concern is usually expressed about the surplus revenues which marginal-cost pricing would yield, and the problems and complexities involved in dealing with them. It is said further that using the inverse elasticity rule to eliminate surplus revenues would be discriminatory and ultimately arbritrary, given the state of the art for studies of demand elasticity. However, as the rate proposals in Volume VIII show, if one uses surplus revenues to lower the customer charge while still basing the end rate on marginal cost, then the administrative problems largely disappear. Marginal use of electricity would be priced at marginal cost, thus providing the customer with an added incentive to be frugal. At the same time, the revenues each customer group produced would just meet that group's revenue requirement based on historical accounting-costs.

Another important concern of the proponents of FDC pricing is the adoption of time-of-use pricing, which would allow prices to track costs more closely. It is feared that such pricing may lead to shifting peaks and impose more costs than benefits on society because of added metering and administrative costs. The study team shared these concerns. Cost-benefit analysis was undertaken to study the feasibility of time-of-use pricing based on marginal costs. As the rate proposals indicate, time-of-use pricing is feasible for large users across the board. At present cost-benefit analysis does not appear to justify introducing time-of-day rates for the smaller users. The problem of the shifting peak appears to be an illusory one, because of the proposed use of the customer's average monthly non-coincident peak in the peak period for billing demand, as well as the broad definition of the peak period.

Since to apply fully distributed average-cost pricing would keep electricity rates below the level which would correctly reflect the costs of additional service, the traditional fully distributed embedded-average-cost pricing has fewer advantages than marginal-cost pricing.

III. CONSERVATION AND ELECTRICITY PRICING

This section analyses the alternative pricing-objective of conservation, and the rate structure required to achieve it.

Part A defines conservation and addresses the problem of specifying which natural resources are to be conserved.

Part B briefly outlines the analytical framework required to account for other costs besides marginal intracompany costs.

Pricing-problems of intergenerational transfer form the subject of Part C.

Part D provides a brief overview of some drawbacks to a rate structure under which conservation would be a main objective of pricing.

Appendix III is not explicitly referred to in the body of this section, since its analysis is applicable in many areas. It first reviews the problem of conservation from a global, national, and provincial perspective. The appendix is mostly concerned with setting out the rate structure required to achieve a conservation objective, namely inverted rates. Also studied are five policy alternatives for pricing electricity to encourage zero or low energy growth. Before the conclusions, the experience and situations in Sweden, Japan, and Mexico are discussed.

A. WHAT IS CONSERVATION?

1. Conservation Defined

> *There are a great many people in favour of conservation no matter what it means. -W.H. Taft*

The conservation movement has grown out of four distinct concepts, namely:

1. To preserve wildlife and forests (this originated in Europe).
2. To widely distribute ownership of natural resources, and access to them.
3. To prevent depletion.
4. To manage common property resources, such as oil and gas, and the fisheries.

The fact that conservation may mean something very general ("All resources of the earth must be wisely used and replaced") or something very specific ("Protect the farmlands at the proposed site of the Pickering Airport") has led to considerable looseness in its definition.

It is possible, however, to define conservation in more comprehensive and analytical terminology. Economic theory suggests that conservation is *A redistribution of resource use to the future.* This definition is value-free (that is, conservation is neither good nor bad). The responsibility for establishing a public policy to conserve rests with society in general. If a conservation policy is chosen, the decision is simply one to *increase the potential future rates of use of one or more natural resources above what they would be in the absence of such policy, by current investment of the social income.*[6]

The opposite of conservation is depletion, which is a redistribution of resource use rates to the present. Depletion is not necessarily wasteful. Waste is added consumption of a good because prices are less than costs per unit that society incurs in its production. The accompanying graph may help to make this clear.

If a policy increases the service a resource renders at a given time, one can attach a positive value. Example: $\Delta X_i < O$. If a policy leads to a decrease in service rendered, the example would be $\Delta X_i > O$.

Thus, over any given time period from year 1 to year n some x's will be positive, while some will be negative. In discounting this cumulative series, equal magnitudes diminish in value the more remote they are in the future. If the cumulative total of the changes is greater (less) than zero, the policy is one of conservation (depletion).

It should seem that any policy decision to 'conserve' ought necessarily to be based upon a cost-benefit analysis of the proposal. Given this, conservation is only feasible if the future benefits from postponing current consumption are greater than the present benefits from consumption today.

Before discussing the implications of a conservation policy, it may be useful to examine what Ontario Hydro would or should conserve.

2. Resource Classification

The characteristics of the resources to be conserved are vitally important in defining the implications of a conservation policy.

In the strict sense of the definition, electricity may be conserved. However, in the redistribution of rates of use of electricity to the future, the dollar benefits which accrue are in terms of the fewer inputs required to the present process of producing, transmitting, and distributing electricity. In other words, a more accurate description of a policy decision by Ontario Hydro to conserve would be one that mainly stressed redistributing the resource-use rates of oil, gas, coal, uranium, water, land, and capital to the future. These would be conserved by raising rates through shadow pricing of electricity. The shadow prices would reflect the marginal intergenerational transfer costs of using electricity now. The resources that the utility would try to conserve may be roughly categorized as follows:

1. Exhaustible or Inexhaustible,
2. Non-Renewable or Renewable, and
3. Stock or Flow.

It must be noted that exhaustibility and renewability must be defined in *economic* rather than physical terms. Long before physical exhaustion, a resource may become economically exhausted, if the costs of recovery and use outweigh the benefits.

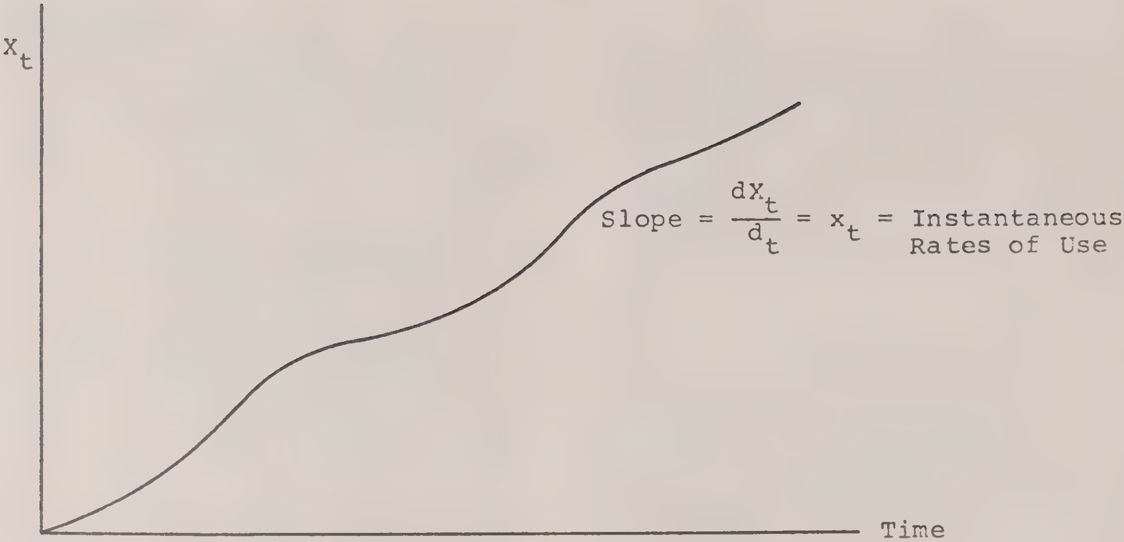
a. Exhaustibility

Resources exist in limited quantities, and can be entirely used up, economically speaking. Exhaustibility is related to accessability of location and quality of the remaining stock. Moreover, changes in demand or technology may affect the point at which a resource is considered economically exhausted. While all resources would seem to be potentially exhaustible, the utility will no doubt consider some resources inexhaustible, either because of limited use (uranium, for example) or because they are renewable (water, air, or labour). Note, however, that any comprehensive analysis of exhaustibility must consider limited use in the national or in the global context.

b. Renewability

The availability of some resources can be augmented or renewed over time, whereas others are fixed. Some resources may be renewed periodically by nature (air and water, for instance) and some by investment of human effort, provided the benefits outweigh the costs. Other resources (such as oil, gas, coal, and uranium) cannot be renewed, although substitutes might possibly be found.

[6] Anthony Scott, *Natural Resources: The Economics of Conservation* (1973), p. 30.



Where X_t = Cumulative use of the resource

t = Any given time period

And $$X_t = \int_1^N x_t d_t$$

Total or cumulative use of the resource is the sum of individual instantaneous rates of use of the resource (one second, day, month, year, or whatever).

c. Stock Versus Flow

A stock resource is one the physical supply of which does not increase significantly with time. Such a resource may be either exhaustible or inexhaustible from an economic point of view, but is not renewable. The amount of a stock used at one time diminishes the amount available later on.

A flow resource is a resource to which further quantities are added over time. These successively available quantities constitute the flow. The increments (or flow) can be affected by human involvement. It is dangerous to generalize flow resources as renewable or inexhaustible, since they may still be destroyed through the intervention and exploitation of society. Some implications of the distinction between stock and flow resources are these:

1. The way stock resources (oil and gas) are used suggests that *technology* plays a dominant role
2. In the use of flow resources, economic and social institutions are probably decisive. For example, use of water is sensitive to water and land rights and the laws governing them.
3. Flow resources with critical zones (A more or less clearly defined range of rates below which a change in flow cannot be reversed economically under presently foreseeable conditions) give rise to serious economic and social problems of depletion. Examples are plant and animal species, or the scenery near proposed generating-plants.

The trade-offs between the benefits and costs of conserving stock or flow resources are not intuitively obvious. For example:

1. Technology may render stocks obsolete. For example, solar power may make oil or gas uneconomic.
2. Care must be taken not to deplete flow resources into critical zones.
3. At the same time, while some flow resources are not used up (in a consumption sense) but merely used, their quality is nevertheless greatly impaired. For example, while a dam does not physically use up water, it destroys the characteristics of the river for some distance upstream and down.

To conclude, the question of conservation is not as clearcut as it is often considered. Both the act of conserving and what one is

trying to conserve must be clearly defined. From the discussion, it would seem that the question of when to consume a particular natural resource is one for society as a whole to answer. As such, a decision unit as narrow as a utility within a single province may be inappropriate as a basis for decision criteria on resources that are more properly viewed in a national or at least provincial domain. In other words, costs of intergenerational transfers ought to be internalized in a decision unit that better represents the overall consensus of society. Nevertheless, if it is considered worthwhile for a single utility to follow a policy of conservation, there are pricing mechanisms to achieve a reduction in present rates of use of electricity. Such a pricing-scheme is the subject of Part B

B. PRICING FOR CONSERVATION

An assumption required before continuing is that specific natural resource inputs within the corporation may not be individually priced to encourage conservation. For a grid, cost-pooled power system such as Ontario Hydro's, conservation simply means reducing the use of electricity. The approach may not aim specifically at reducing consumption of electricity produced by burning oil or gas (supposing it were deemed necessary to conserve either of those two fuels). However, given the utility's load-duration curve, it is apparent that the fuel used in the least efficient of the plants fired with those fuels would be the first to be saved as conservation took effect.

1. Analytical Framework

The price of electricity in a system that incorporated the alternative pricing-philosophies of Sections III, and V of this volume would appear as follows:

$$P = MC_p + MC_{it} + MC_e$$

That is Electricity Price = Private Marginal Cost + Intergenerational Transfer Marginal Cost + Environmental Marginal Cost.

The marginal private cost is the marginal input cost of electricity (production, transmission, and distribution). The marginal environmental cost is that extra cost incurred to offset the environmental costs to society of producing, transmitting and distributing electricity. The marginal intergenerational transfer costs are the costs that current use of resources to produce, transmit, and distribute electricity imposes on future users. Those are the costs this section is concerned with.

Technically MC_{it} could be either positive or negative, indicating a policy of conservation or depletion respectively. But if one restricts it to a positive value (as in practice), then the equation suggests that current consumption imposes an increased cost of production on future generations, so that the optimal price of the resource must exceed its current marginal resource cost. This cost is not an externality; "it is rather a case where a certain quantity of resources is available to a group of individuals, so that the more that is consumed by one of them, the less there is left for the others".[7]
The result, then, is a redistribution over time of the available stock of resources.

Thus MC_{it} is an opportunity cost of present production of electricity. This opportunity or user cost is the future benefits (discounted) from postponing current consumption to some specified later date. A precise definition of user cost is 'The present value of benefits that could accrue on an extra kilowatt-hour of electricity generation if its production were postponed to the best future date'.

Theoretically, then, a utility ought to increase its generating-capacity until the marginal current benefit equals the marginal cost to the user. Following this course would maximize the present value of the production of electricity over time.

C. PRICING-PROBLEMS OF INTERGENERATIONAL TRANSFER

1. Measurement

The theoretical and operational difficulties of developing a shadow price Ontario Hydro could use for conservation may be insurmountable. The problems are three-fold.

a. The opportunity or user cost of present electricity production is rather hard to measure. The difficulty is that the concept of user cost assumes property rights over the resource now and in the future. Lacking ownership rights to its future fuel resources, Ontario Hydro cannot know their true user cost, and so must ignore that in its primary decision.

b. Furthermore, whether the dollar costs and benefits of conservation can be calculated is questionable. What is the value of having an extra kilowatt-hour or gallon of oil at some point in the future? Do the costs of postponing using electricity today outweigh the benefits a future generation would derive from being able to use more? As a final hindrance, cost-benefit studies of intergenerational transfers are only in their infancy.

c. If a cost-benefit study on conservation is nevertheless undertaken, difficulties will be encountered in choosing a proper discount rate to apply to future benefit and cost streams. Choosing the wrong discount rate when analysing benefits of intergenerational transfers, could lead to misallocating resources over time. For example, too high a discount rate would disadvantage future generations, because the value of the resource rapidly decreases the further one moves from the present. Conversely, too low a rate would suggest the resource held considerable value for future generations.

   Much has been written about choosing an appropriate rate of discount.[8] Suffice it to mention here that the social rate of time preference is often used to trade consumption today for consumption tomorrow. Proponents of this discount figure (Marglin, Sen, and Eckstein) suggest that the investment market reflects the result of individual, atomistic savings and investment decisions. Therefore, the market gives little weight (if any) to the preferences of future generations, tends to save "too little", and yields a rate of interest that is "too high". One of the arguments often used against a social rate of time preference is that provision for the future is unnecessary, because historically future generations have always been wealthier than present or past generations.

[7]Baumol and Oates, "On Optimal Pricing of Exhaustible Resources", p. 68 in *The Theory of Environmental Policy* (1975).

[8]For further information see Baumol, "The Social Rate of Discount", *American Economic Review (September 1968). pp 788-802; Eckstein, Water Resource Development: The Economics of Project Evaluation* (1961); Marglin, "The Social Rate of Discount and the Optimal Rate of Investment", *Quality Journal of Economics* (February 1963) pp. 77 and 95-112; Mishan, "Criteria for Public Investment", *Journal of Political Economy* (1967), pp. 139-146; Lee and Orr, "The Private Discount Rate and Resource Conservation", *Canadian Journal of Economics* (August 1970), pp. 351-363; and Sen, "On Optimizing the Rate of Saving", *Economic Journal* (September 1961), pp. 71 and 479-96

2. Societal Inefficiency

If one could estimate a reasonably accurate opportunity or user cost for present electricity production, societal inefficiencies could still develop. One cannot conserve kilowatt hours as such, but one can conserve the inputs required to produce them. Thus, the utility cannot be sure the pricing of those inputs has not already taken intergenerational transfer costs into account. The danger of 'double counting' at this point is to make electricity prices artificially high, and so turn customers to alternative sources of energy. To prevent these distorted price signals, it would seem logical to leave the responsibility for seeing that pricing to conserve with the agencies or groups that possess the resource in its 'natural' or 'unprocessed' state. At that point, pricing to maximize present value over time would lead to using the resource efficiently in all sectors of the economy.

D. THE DRAWBACKS OF AN INVERTED RATE STRUCTURE

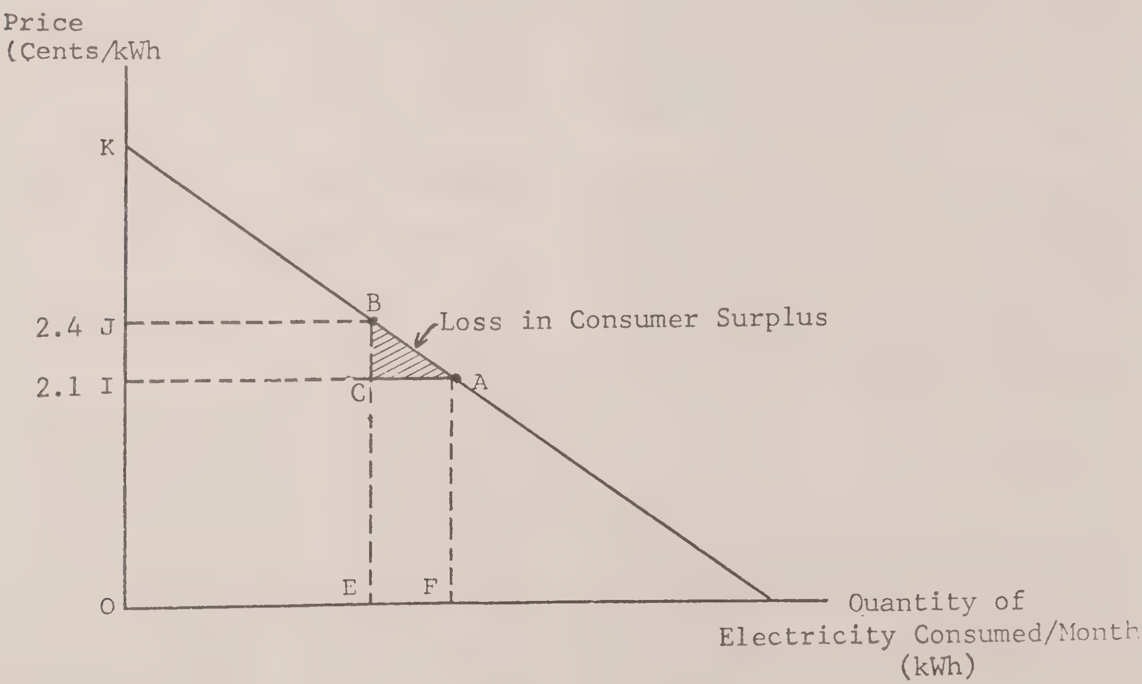
Conservation movements have suggested that electric utilities should price electricity so as to achieve zero energy growth. The growth rate for electrical consumption can be forecast by combining analysis of the rate structure with knowledge of demand elasticities. The rate structure usually proposed to meet this objective is one of inverted rates. Inverted rates are simply demand and energy charges which increase in some step fashion with the number of kilowatts or kilowatt-hours the customer takes. The structure is designed to discourage use of electricity, especially heavy use, through charging arbitrarily high prices. Since this rate structure no longer reflects the costs the utility incurs, inefficiencies arise. A rate structure not based on costs would distort the allocation of resources devoted to producing electricity, both at any given time and through time. Moreover, inverted rates would change the heavy users' elasticity of substitution between electricity and other goods and services. The effect on the welfare of large users may be illustrated in a hypothetical example such as the accompanying figure.

1. Assumptions

1. The demand curve for purposes of this example is linear.
2. The marginal cost of electricity without inverted rates is 2.1 cents per kWh.
3. Inverted rates for these customers means a marginal cost of electricity of 2.4 cents per kWh.
4. Constant marginal utility of income is assumed for all customers as the price of electricity or any other good changes.

The effect of introducing a conservation-oriented pricing-system through inverted rates is to shift the price from A to B. Consumers are willing to pay OKBE for electricity. They actually pay OJBE. The consumer was willing to pay OKAF when the price was at A. The change in what the consumer is willing to pay is EBAF. Of this amount, ECAF consists of fewer costs, so that the net loss in benefits of consuming electricity is given by the shaded triangle CBA. This triangle measures the loss in consumer surplus due to the introduction of inverted rates.

Beyond the loss of welfare, inverted rates would redistribute wealth in uncertain ways. Since an inverted rate structure, like any other, must produce revenues to equal the revenue requirement, there will be cross-subsidization among users of electrici-



ty. Inverted rates could differ from rates based on marginal cost in several ways. Initial blocks of use could be priced at marginal cost, with a gradual increase in rates as consumption increased. Any further surplus revenues besides those already accumulated through marginal-cost pricing could be applied to reduce the customer charge. A variant of this method would be to apply the surplus revenues to the initial blocks. This, then suggests a pricing-system under which low users would receive electricity at prices below their marginal costs. But since rates would increase with use, large users would face rates higher than marginal cost. Either method would redistribute wealth from the large users to the small ones.

2. Conclusion and Summary Recommendation

A cost-minimizing public utility ostensibly should achieve conservation, or some desirably low growth rate for energy, through a clearly defined policy, rather than by distorting rate structures. There is reason to believe that the market for scarce non-renewable resources will not misallocate them over time. Since resources of this type are mostly held by major corporations and governments, it could be rationalized that it is in their long run best interests to maximize the current value of the resource over time.

As W. Baumol put it,

> *An ideal futures market for our scarce resource can lead to current prices that reflect fully the social costs of consumption of the item. The market may be able to achieve this even if the rise in costs is introduced through a switch in technology and a concomitant change in the source of the output (input) in question. If exhaustion of our petroleum reserves simply hastens the day when we will have to make use of solar energy which, we may assume, will be very costly to process, the price of oil will rise as the date of substitution approaches, because of its rising opportunity cost; in a competitive market, this will be reflected as a higher current price.*[9]

Clearly, electricity is not a directly depletable resource. As such, it is not within the mandate of an electric utility to deal with the optimal pricing of depletable resources that effect conservation. However, it is incumbent upon the utility to ensure that its pricing policy does not encourage the wasteful use of its product.

Therefore, given the above arguments, it is recommended that

> *Ontario Hydro should reject inverted rates, and the theory of conservation they imply, as a primary basis for pricing.*

[9] Baumol and Oates, "Optimal Pricing", p. 69

IV. RETAIL RATES OF ELECTRIC UTILITIES AND THE OBJECTIVE OF SOCIAL WELFARE

A. INTRODUCTION

If a primary object of pricing were to achieve a set of social welfare objectives and so help electricity users with low incomes, the cost-based rate structure would have to be changed. Any change in the rate structure that is not based on costs will redistribute wealth. This section will examine the issue of using the rate structures of utilities for income redistribution.

With any program to redistribute wealth, there are three basic questions:

1. *Who is to benefit from the program?*

   This paper is primarily concerned with redistribution in favour of low-income customers. However, the feasibility and desirability of redistributing wealth in favour of industry is briefly examined.

2. *Who is to pay for the program?*

   The analysis will largely consider programs requiring Ontario Hydro financing.

3. *What are the policy instruments to be employed in answering the first two questions?*

   The policy instruments outlined are lifeline rates, energy stamps, and tax credits. The overall implications of using Ontario Hydro as a policy instrument to redistribute wealth through its rate structure will also be assessed.

Briefly, the findings of this section are:

1. Redistributive schemes requiring Hydro financing conflict with the corporate objective.
2. Lifeline rates have many disadvantages, and are therefore unacceptable as a way to redistribute wealth.
3. Energy stamps and tax credits are more attractive than lifeline rates, but still have serious theoretical and practical drawbacks.
4. Redistributive policies favouring industrial decisions about location or growth involve the same problems as lifeline rates and energy stamps.

The appendices to this section briefly analyse some of the broader issues within the topic of redistributing wealth to promote social welfare.

Appendix IV considers the issue of who is responsible for redistributing wealth in today's society.

Appendix V examines the results and structure of current government policies for redistribution.

Appendix VI describes what some may consider an efficient redistributive mechanism, namely, a negative income tax.

B. ENERGY SUBSIDIZATION TO REDISTRIBUTE WEALTH

Ontario Hydro's mandate is to meet the electrical demands of the province at the lowest feasible cost. Achieving this requires an efficient pricing system. Such a pricing-system necessarily conveys to the consumer the cost which the supplier will undertake to produce electric power. Social engineering through rates or any intentional cross-subsidization of some users of electricity by others should not be within the Corporation's mandate. Furthermore, unless the government so decrees, the Corporation should not be used as a policy instrument for redistributing wealth. Cross-subsidization effectively nullifies cost causality and an efficient pricing-system. Cases A and B will examine two separate cases of redistribution.

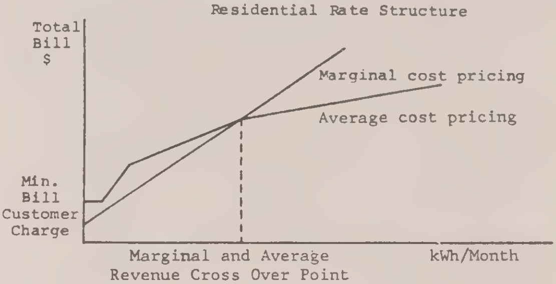
C. CASE A: REDISTRIBUTING WEALTH IN FAVOUR OF 'POOR' RESIDENTIAL CUSTOMERS

The question of subsidized energy use is only now coming before the Canadian public. It will therefore be worthwhile to review and comment on various proposals, in anticipation of the growth of interest in such programs in Ontario.

Pressures for redistributive programs increase as spending on energy becomes a larger share of the household budget. The intended benefactors of redistributive schemes are usually the lower-income groups.

Ontario Hydro should be independent of society's redistributive programs and should only take a position on the merits of schemes that would specifically require its direct involvement.

It should be noted that, compared to the present system, marginal-cost pricing would provide lower bills for customers using few kilowatt-hours. The recommended structure for residential rates, which would dispose of surplus revenues by lowering the customer charge, would also help to ease the burden of rate increases somewhat for such customers. A low customer charge, combined with a flat charge per kilowatt-hour, yields impact effects similar to those under lifeline rates. Customers whose use fell below the crossover point between charges under marginal and under average costs could have lower bills than they would if the declining-block rate structure were maintained. The accompanying graph illustrates this.



Thus even though the main justification for marginal-cost pricing is efficiency, it can help to attain some social objectives. But like any redistributive scheme in a firm aiming to minimize costs, marginal-cost pricing is no cure-all for the problems the poor face in trying to meet the cost of energy.

Case A will analyse the following possible programs:

		Revenue Source	Program Administrator
1.	Lifeline Rates	Hydro	Hydro
2.	Energy Stamps or Vouchers	Hydro	Government
3.	Tax Credit	Hydro or Government	Government

1. Lifeline Rates

A lifeline rate may be defined as a low uniform charge for the first several hundred kilowatt-hours per month each residential customer uses.[10] The charge is lower than the costs of providing the service.

[10]See J.D. Pace, *Lifeline Rates and Energy Stamps*, (1975), pp. 2-3. This section draws on two papers by Pace and one paper by J. Joskow of National Economic Research Associates, Inc.

An implicit assumption in establishing a lifeline or redistributive program is perfect correlation between electricity use and income, so that the rate structure will be progressive and fair.[11] The lifeline practice is simply one of redistributing wealth through cross-subsidization of low use residential customers by other electricity users. There are various ways to make up the revenue such a scheme loses, and the burden imposed on others will vary according to the method. All methods, though, involve recovering lost revenue through increasing rates for use above the lifeline level. The most likely approach would involve having the other residential customers subsidize all or some of the lifeline rates. Some of the costs could perhaps be covered, however, through higher industrial and commercial rates.

The following is an analysis of the advantages and disadvantages of lifeline rates:

2. Stated Advantages of Lifeline Rates

a. Ease of Implementation and Administration

Lifeline rates are easy to understand and may be undertaken with little delay.

b. No New Tax Revenues Required

This stated advantage may be attractive to the government because of two factors:

1. Lifeline rates appear as an indirect or 'hidden' tax on the customer, using electricity at a level above the lifeline.
2. The government is not directly involved in the program.

Lifeline rates are an attractive opportunity for governments to pass on some of the burden of financing their own social-welfare programs to retailing utilities. The increased public awareness of government spending may provide an incentive for politicians to examine the concept seriously.

c. Public Support for the Concept

The lifeline concept has received the support of the Consumer Federation of America.[13]
Ontario consumer groups might at first support a proposal which appeared to reduce the electricity charge to low-income families.

d. Will Encourage Conservation

Lifeline rates are said to encourage conservation by providing favourable rates for basic and necessary uses of electricity and higher rates for greater and less essential use.[14]

3. Problems Associated with Lifeline Rates

a. Questionable Help to Poor

Several considerations suggest that lifeline rates would not, in fact, adequately help the poor.

1. The poor who are lodged in master-metered apartments would probably not be eligible for lifeline rates. Since commercial customers may be helping to subsidize lifeline rates, tenants in master-metered apartments would probably face higher rents as their landlords passed on increased costs to them.
2. Low-income families using relatively large amounts of electricity would get little or no benefit from a standardized lifeline program. Examples are poor farmers, or those with electric space and/or water heating.
3. Canadian data on the above are not readily available. A U.S study revealed that in 14 states, a lifeline plan would leave out more than half the poor. In another 25 states, it would bypass more than a fourth.[15]

   The study revealed that the poor used more electricity (over and above the lifeline level) the further north they were located. The relatively severe Ontario winters, combined with the likelihood that the poor would live in housing lacking such energy-saving features as insulation and adequate storm windows, might suggest that many families with low incomes nevertheless use a good deal of power. Therefore, the assumption implicit in the lifeline approach that low income matches low usage appears even more questionable under Ontario conditions.
4. Lastly, this policy, though designed to help the poor, in no way excludes low users with higher incomes. A well-to-do customer who used electricity at levels below the established lifeline would receive as large a subsidy as anyone else.

An interim study correlating data from Ontario Hydro and the municipal utilities with the Labour Force Survey of Statistics Canada for 1974 showed that:

1. For households earning less than $6,000 a year in total,
   a. Such households made up 18.5 per cent of the whole sample;
   b. Of households using less than 250 kilowatt-hours a month, 0.8 per cent comprised six persons or more;
   c. Of households using more than 1000 kilowatt-hours a month, 10.6 per cent comprised six persons or more; and
   d. Of households using more than 500 kilowatt-hours a month, 56.5 per cent lived in dwellings built before 1940.
2. For households earning more than $15,000 a year in total,
   a. Such households account for 36.6 per cent of the whole sample;
   b. Eighteen per cent used less than 500 kilowatt-hours a month;
   c. Of households using less than 250 kilowatt-hours a month, 6.6 per cent comprised six persons or more;
   d. Of households using more than 1000 kilowatt-hours a month, 27.7 per cent comprised 6 persons or more;
   e. This group owned 73 per cent of all dishwashers, 50 per cent of all washing-machines, 50 per cent of all clothes dryers, and 49 per cent of all air conditioners.

---

[11]A brief discussion of fairness, especially in the context of a rate structure, can be found in Appendix IV
A current Ontario government document, the *Report of the Special Program Review - 1975* (Henderson Report) reflects and supports the probable appeal of any method of reducing provincial government spending. In fact, the review's mandate reads in part, "to inquire into ways and means of restraining the cost of government through ... *alternative lower cost means of accomplishing objectives*' ('lower' cost here probably means lower to the provincial government, not to society). Refer to Appendix V for evidence of the growth of government spending in the area. It would appear that any program to reduce government spending, or slow it's growth, is politically expedient at this time.
[13]See J.D. Pace, *The Poor, the Elderly and the Rising Cost of Energy*, (presentation Before the Pennsylvania Power Conference, Hershey, Pennsylvania, April 1975), p. 3
[14]Pace, The Poor, p. 3
[15]National Economic Research Associates, Inc. Pamphlet, *Lifeline Rates and Energy Stamps*, Presented at NERA Conference on Peak-Load Pricing and Lifeline Rates, New York, 1975

The foregoing data support the argument that lifeline rates would not efficiently help the people they were meant to. While household use does bear some relation to income, other factors also have an important effect, notably how many appliances the household own, what sort of housing they live in, and household size. To the extent that the above data is representative, the institution of lifeline ratio would appear to be a relatively inequitable and inefficient tax or transfer measure.

b. Lifelines May Not Aid 'Conservation[16]

Conservation generally means consuming less, or avoiding waste. Generally, lifeline rates and conservation depend on the method of recapturing lost revenue, and the elasticity of demand of high and low users of electricity.

Two cases are considered here.

In the first case, assume that the revenue lost because of a lifeline program is recovered from commercial and industrial rates. In the second case, assume an inverted residential rate structure. In both cases, there may be increased residential energy use, because every residential customer's lifeline kilowatt-hours will cost less, and thus the total bill will be lower for many residential customers. This effect will be more pronounced under the first of the two cases.

Customers facing higher rates and total bills may be expected to decrease the rate at which they use electricity. However, the opposite will hold for customers with decreased rates and/or bills. The size of these trends is a function of the respective elasticities of demand of high and low users of electricity.

The aggregate results on the rate of use of electricity is, at best, inconclusive for the present.

c. Lifelines are a Second-best Solution

A lifeline policy would create difficulties in using other energy sources. It would have some customers paying a price for electricity which is below the cost of providing it. This would distort the consumer's choice between electricity and gas or oil, and hence his use of these energy sources.

There is another reason for thinking lifeline rates would do little to help those that suffer most from the rising costs of energy. In most households the largest item by far in the energy bill is heating; but in 1974, 93 per cent of those Ontario households earning less than $6,000 heated their dwellings with oil or gas, not electricity.[17]

d. How to Recover Lost Revenue

There are many ways to raise the revenue needed to finance such a program.[18]
For example, the shortfall could be recouped from commercial and industrial rates, from all residential customers, or only from residential use above the lifeline level. Trying to decide which is most appropriate would undoubtedly lead to conflicts between and within customer classes. Once this financing-burden was distributed, the direct problem over which Hydro has some control would be solved. However, the indirect effects of the chosen method should be considered.

Supposing, for example, that an industrial customer faced a rate increase because of lifeline rates, the question of incidence would be one of who in the end absorbed this rate increase. Would it be the industrial user himself, or his customer, or (as is likely) some combination of the two? Where the incidence lay would, of course, depend on the customers' elasticities of demand for the products of the company facing the rate increase.

In fact, lifeline rates could sometimes leave the low user of electricity facing higher prices for the goods produced by the industries and commerical firms that had to subsidize his lifeline use.

Thus a program such as lifeline rates would introduce distortions into the everyday market mechanism: distortions which might, after reverberating through the economy, cancel out the benefits of the program.

e. Lifeline Rates Might Arouse Criticism

Depending on how the lifeline rates were financed, there would probably be critisism from industrial, commercial, and high-use residential customers. Moreover, because of the potential for increased use of energy, conservationist groups might be opposed. These are examples of the conflicts a redistributive policy could produce.[19]

f. Uncertainty about Setting the Proper Lifeline Level

A policy decision would be required to select a lifeline level reflecting the minimum amount of electricity needed to power basic household equipment. The many variables affecting such a decision would make the choice a hard one.

4. Energy Stamps or Vouchers.

Energy stamps are an example of a redistributive policy which might be financed and administered by the government. As they have been proposed in the United States, energy stamps would go to those who qualified for them through a direct means test. Thus the program would resemble the present one for food-stamps in that country. The stamps or vouchers would be used to pay either electric or fuel bills. The vouchers (unlike the stamps) would have the advantage of not being transferable from the recipient to others.

5. Stated Advantages of the Proposal

1. Unlike lifeline rates, energy stamps may be used to pay gas, oil, or other types of fuel bills, as well as electric bills.
2. Fuel stamps can provide variable level of aid depending on need, unlike lifeline rates which are insensitive to need.
3. With energy stamps the poor are identified and helped directly. This is a distinct advantage that energy stamps have over lifeline rates, which rely upon use of electricity as the basis for allocating subsidies.

6. Problems with Energy Stamps

1. In the United States the eligibility standards would parallel those for current food-stamp or other public-assistance programs. In Ontario, on the other hand, the costs of administering an energy-stamp program might be substantial, since the province has no food-stamp program. Only a few Ontario aid programs conduct a means test. Moreover, Canadian welfare schemes have shunned stamp programs precisely because they publicly identify the poor. Such a social stigma can produce psychic costs difficult to estimate.

---

[16]Conservation is simply a redistribution of resource use to the future. Whether that is good or bad is for society to decide (see Appendix I on conflict versus concensus criteria within society and also Section IIA and above).

[17]Data reached by co-ordinating 1974 Survey of Consumer Finances with statistics from Ontario Hydro and municipal utilities.

[18]Assuming a marginal-cost pricing-system, applying the inverse-elasticity rule would minimize distortion. That is, optimality would be disturbed least when the prices facing those customers bearing the burden diverged from marginal cost inversely to their own price elasticities of demand for electricity.

[19]Refer to Appendix IV for a discussion of how it would be inappropriate for Ontario Hydro to become involved in areas of disputed criteria. Any rate structure that failed to relect costs and the cost causality would inevitably give rise to cross-subsidies and conflict.

2. If Ontario Hydro were to finance part of the revenue accumulation program, a quasi-sales tax on electricity would be necessary. In order not to distort relative prices between various sources of energy, one would in effect have to place an excise tax on other energy rates. This type of tax and the resulting mechanism for revenue accumulation changes consumer preferences. The post tax price signals will affect marginal rates of substitution between energy and other goods and services within the economy.[20]
3. There is no indication to what extent the public would accept such a stamp program. For example, American government sources estimate that only about half of those eligible for food stamps apply for them.[21]
   There is little reason to believe that the Ontario reaction to a stamp program would be any more encouraging.
4. Issuing energy stamps or vouchers would imply that the issuing authority (whether Ontario Hydro or any other) had the power and right to discriminate between customers on the basis of their wealth: in other words, to authorize lower bills for the poor than for other individuals. This would be unprecedented in Canada.

7. Tax Credit

A system of tax credits for energy or electricity could be developed similar in form to the Ontario property-tax credit system. Individuals and families would receive tax rebates based upon their use of electricity. They would have to keep their bills for electricity and/or other energy as proof of actual use.

Of the three redistributive schemes outlined, energy tax credits might seem the most attractive alternative, for the following reasons:

1. They would minimize distortions in consumption preferences between energy types within the economy.
2. The poor would be more easily and more accurately identified.
3. The use of tax credits would be a move towards a negative income tax.

Ontario Hydro ought to be more or less indifferent if the program were funded out of government coffers. However, even though the direct effect of such a program upon the utility would be minimal (involving no need to change rates). the indirect and induced effects might be substantial. These would be effects on the demand for electricity and on load growth from (practically speaking) pricing electricity below its cost.

In summary, like lifeline rates, energy stamps and tax credits carry deficiencies that make them inadvisable. The chief one is the inefficiency and waste that could result from offering electricity to some users at prices that did not reflect its costs. Another problem area is the difficulty of financing any cross-subsidy on a justifiable basis. That is, conflict criteria are difficult for a Crown corporation to administer. As was mentioned, fixed surcharges are regressive, while a progressive rate structure does not absolutely correlate with rising income.

Appendix VI briefly outlines a possible solution to this problem. A negative income tax system would remove the need for piecemeal programs.

D. CASE B: REDISTRIBUTION OF WEALTH IN FAVOUR OF INDUSTRY

While subsidizing low-use residential customers is inadvisable, the same holds true for users of electricity subsidizing industrial growth or establishment. It could be argued that subsidizing industry through special rates would encourage economic growth, rising incomes, and/or full employment. Whether that is true or not, the suggestion would conflict with the utility's mandate just as much as Case A.

Each new or expanding industrial or commercial customer should normally be charged a rate reflecting the cost of his purchase of new or added power. Otherwise, Ontario Hydro might encourage wasteful use of electricity. Unless the customer knows the true cost consequences of his consumption decision, second-best considerations (from the standpoint of a cost benefit analysis) will prevail.

If the government should wish to influence companies' decisions about whether to grow or where to locate there are lower-cost alternatives. For example, a lump-sum subsidy to a firm, based on a cost-benefit or cost-effectiveness analysis, could serve the purpose. This approach would allocate the fiscal burden of distributing wealth through the national and provincial tax structure. On the other hand, for Ontario Hydro to provide a subsidized electrical infrastructure to a chosen few would not accomplish that. Instead it would spread the fiscal burden among the remaining users of electricity. The distribution of patterns of use of electricity among customers does not coincide with the distribution of wealth in society.

Many of the arguments put forward in the previous case apply here too, and therefore will not be repeated. Suffice it to note that Ontario Hydro would not be justified in letting any one class or group of electricity users cross-subsidize any other as a way to redistribute wealth. The problems posed by conflict criteria are properly the responsibility of governments, not Crown corporations. Furthermore, to do so would badly undermine the Corporation's objective of efficiency.

If Ontario Hydro is to have a pricing-structure consistent with efficiently allocating resources devoted to producing electricity, it should not let such conflicts enter into its operation. Policies for redistributing wealth can cause inefficiencies, because under them not all persons within the market mechanism are faced with prices reflecting the cost of production. Therefore, however excellent the intentions, manipulating the cost-minimizing calculations of Ontario Hydro and its customers is an inefficient way to correct the distribution of wealth. The inefficiency lies in the distortion of the marginal rates of substitution the household faces in its decisions about consumption, and marginal rates of technical substitution that industry faces in its decisions about production. Whatever distribution is desired can be attained more efficiently through a progressive system of income tax than through *ad hoc* adjustments within a single market.

E. CONCLUSION

Imposing redistribution of wealth on Ontario Hydro would lead to

1. Inefficient allocation of resources used in producing goods and services within society.

[20]On the producer's side, the only time such a distortion is minimized and the pricing-systems remain nearly optimal would be when each energy price (after tax) is set so that its percentage departure from marginal cost is inversely proportionate to the firm's price elasticity of demand. On the consumer's side, changing the relative prices of goods in the economy would interfere with allocating resources efficiently through the mechanism of the market.

[21]U.S. Senate Select Committee on Nutrition and Human Needs. "Special Groups Report No. 2: Food Stamps", *Report 4*, Part (March 1975)

2. Inefficient allocation of resources devoted to producing electricity at the lowest feasible cost.

3. Inefficiency in identifying and helping the poor in a least-cost manner.

On the other hand, redistribution of wealth through a system of negative income tax has some distinct merits compared to the other schemes.

1. It would make use of a taxing-structure already available, which would make it comparatively cheap to introduce and administer. Moreover, being centralized, it would run less risk of treating equals unequally, as often happens where there are many small unco-ordinated aid programs.

2. The most readily acceptable measure of affluence or poverty in today's society is income and wealth. Unlike most other redistributive schemes, a negative income tax system withdraws or supplements these stores directly.

3. Using the national and provincial tax system to redistribute wealth would affect all citizens, regardless of how they spent their money. One could not say the same of any redistributive scheme for subsidizing purchase of one or more selected commodities.

4. Finally, and perhaps most significantly, supplementing individual or family incomes to minimum levels with no purchasing ties attached would not distort consumption preferences. However, any program that changes the price of one commodity relative to others within the economy distorts the efficiency of the market allocation mechanism. See Appendix VI for further explanation of a negative income tax system.

Ontario Hydro can best achieve its corporate objective, and fulfill its role in and obligations to the province, through maintaining its least-cost curve through time by efficient pricing.

V. PRICING FOR ENVIRONMENTAL PROTECTION

INTRODUCTION

Some have proposed that the primary objective of pricing should be environmental protection. In order to achieve this objective, it is suggested that a shadow price or externality tax equal to the marginal net damages caused by the production of electricity should be added to the marginal private cost to determine the appropriate price for electricity. The National Energy Board has implicitly endorsed this pricing practice for electricity exported to the United States.

The purpose of this chapter is to consider the rationale of this alternative pricing-objective the alternatives available. and the state of the art in measuring external costs. This chapter is composed of three sections.

Section A outlines the problem and provides a recommended definition of social cost for use in Ontario Hydro. It also proposes the net benefit criterion as the relevant test for dealing with external costs.

The issue of shadow pricing as an appropriate pricing-objective is discussed in Section B. Both the case for and case against shadow pricing are outlined. Seven major drawbacks to shadow pricing, or externality taxes, are developed. There is a brief discussion of alternative methods of dealing with external costs.

Section C presents an overview of the measurement of external costs.

A summary of the major recommendations is found at the end of Section C.

A. DEFINING THE PROBLEM

The pollution associated with generating of electricity has become of increasing concern in recent years. Generally, the pollution problem may be generally defined as a situation in which private costs, those faced by the economic decision-making unit, are lower than the true social costs. Consider some examples.

If a factory producing dye-stuffs pollutes a stream with effluents, then it is likely to spoil the taste of whiskey produced in a distillery further downstream. If the whiskey is spoilt, then the total social costs associated with producing dye-stuffs may be greater than the private costs facing the dye-stuff producer.

Another useful example is the manufacture of steel. For purposes of exposition, assume there are no air-pollution control-standards enforced by the government. According to the particular process which is employed, more or less smoke may be discharged into the air as a by-product of steel production. If the producer is a profit-maximizer, he would be motivated to choose that method of production which is most profitable, without regard for the associated level of smoke. The point is that the producer can be considered to dispose of smoke as another resource contributing to the production of steel. This view is justified by the fact that a reduction in the discharge of smoke could only be effected by either adopting an alternative and more expensive method of production or using the same process but with smoke-control devices added. Either alternative involves using additional resources, such as capital and labour; these additional resources are not free. There is no charge, on the other hand, for emitting smoke into the air, so that there is little, if any, motivation to attempt to limit the use of the resource which might be called smoke disposal.

While steel producers might consider the discharge of waste into the air a free resource, it is not without consequence to people who live in near-by communities. Atmospheric emissions from the steel producer may cause more rapid deterioration in the exterior of buildings and textile products, damage crops and animals, and harm the health of at least some of the residents of the community. In other words, the discharge of waste into the air is not a free resource to the community; rather atmospheric emissions are potentially costly. Compensatory resources, labour and capital, may have to be used on more intensive cleaning, maintenance, repair, and health care. Such a situation, where the producer does not bear the full costs of its actions, is an example of the divergence between private costs and the total cost to society. The difference is the external cost. The essential point here is that without some kind of government action, the steel producer has nothing more than possible humanitarian concerns, which conflict with his profit-maximization objectives, to make him take account of the costs that atmospheric emissions impose upon his neighbours.

The effluent of the dye-stuff factory and the smoke of the steel firm are known as externalities. The term externality is defined more formally by economists as follows:

> *An externality is present whenever some individual's (say A's) utility or production relationships include real (that is, non-monetary) vari- ables, whose values are chosen by others (persons, corporations, governments) without particular attention to the effects on A's welfare.*[22]

The definition should not be understood as a simple equation of externalities with economic interdependence; for example, when Mr Jones relies on the farmer for food, no externality need be involved. The farmer does not decide how many zucchini Mr Jones will consume, nor does Mr Jones's consumption pattern enter directly into the farmer's preference function. It should be noted that externalities associated with particular activities can be positive or negative.

The externality is in some ways a straightforward concept, yet in others it is elusive. One of the more difficult aspects of externalities is assigning a dollar value to them. Pollution, for example is an externality. Hence, the external cost associated with pollution is the money value of the damages caused by wastes after they are released into the environment.[23]

The total social cost of producing steel, dye-stuffs, or electricity can be defined as follows:[24]

Total Social Cost = Private Cost + External Costs, where

1. Total Social cost refers to the total economic cost generated by production and market activity of a particular entity.

[22]W.J. Baumol and W.D. Oates, *The Theory of Environmental Policy*. There seems apparently no limit to the trivial externalities people can think up, such as A's envy of B's new car or B's new wife, his disgust at C's body odour, his pleasure at D's promotion or demotion, and so on. These externalities are ignored by economists either (1) because the cost of correcting them (in terms of time, effort, and money) exceeds the potential gain from doing so, or (2) because society at large regards the satisfaction or dissatisfaction experienced as without ethical merit. At present an economist framing policy does not allow for A's envy of B's status, or A's sadistic pleasure in B's suffering. However, in a future society, these may well enter into the calculus

[23]This definition of external costs is based on that of J.H. Dale in *Pollution, Property and Prices*, (1968), p. 13.

[24]This definition is the one economists use. See, for example J. Joskow, "Applying Economic Principles to Public Utility Rate Structures: The Case of Electricity". p 36 in, *Studies in Electric Utility Regulation* ed. C.J. Cicchetti and J.L. Jurewitz, (1975).

2. Private cost refers to those costs faced by and internal to the economic decision unit.
3. External cost refers to the money value of the externalities caused by the production and market activity of a particular economic decision unit upon those persons or decision units who are external to the producing unit's decision-making process and market activity.

The problem of external costs may be clearly outlined. If there are negative externalities (such as pollution) generated either in the process of producing certain goods, or in their final use by the public, then damages are being inflicted on others to which some value may be attached. It follows, then, that the social value of a good (that is, the value remaining after subtracting from its market price the estimated value of the damage inflicted on others by producing the good) may be below its market price. Indeed, it may even be negative. If so, it is necessary to reduce output until the social value of the good is raised sufficiently to equal its marginal cost of production.

Alternatively, it is possible to transform the marginal private cost, calculable which the producer can calculate on strict planning-principles, into marginal social cost. This is done by adding to the private marginal cost the value of any incidental damage inflicted on the rest of society in producing the good in question. When this correction is applied to each unit of any relevant output, the pricing rule for marginal private costs is amended to the more general pricing rule for marginal social costs.[25]

That is how the economist interested in welfare puts a price on those things which, for one reason or another, escape the price mechanism. It is a rule, however, which follows the logic of the market in every respect.

An illustration will clarify the point. A worker offering his services to industry receives in exchange a sum of money that is at least enough to compensate him for the 'ill' or 'disutility' he has to endure, or (to put it more positively) for the good, such as leisure, he has to give up. The wage the worker receives is considered part of the cost of the final product to whose production he contributes. By the same logic, any production activity which creates additional noise, pollution, or other externality imposes an 'ill' or 'disutility' upon others, or has taken a 'good', such as quiet and clean air, from others. The money value of such 'goods', or 'goods' forgone, should also enter into the costs of the enterprise. Thus, a good or service can be regarded as the sum of payments required to compensate others for the losses they would otherwise have to sustain, or for opportunities forgone, yielding private cost plus external cost.

If people are now prepared to pay a price for the finished good that equals or exceeds its total social cost, then it can be inferred that they are willing to pay enough, or more than enough, to compensate all those who have given up something to make the product available. Thus the economic rationale of the commercial rule that price should equal or exceed marginal social cost is simply this: those who gain should be able to compensate, or more than compensate, those who lose.[26]

This 'over-compensation' or net-benefit criterion is the crux of the matter. It is the only criterion of economic efficieny in the orthodox literature on resource allocation. Furthermore, it forms the basis for all popular evaluation techniques such as cost-benefit analysis. If any business enterprise is to vindicate itself as an economic entity, it must ultimately do so by reference to this criterion. All arguments concerning allocation rest firmly on it.[27]

B. EXTERNAL COSTS AND PRICING

1. The Case for Shadow Pricing

The problem of external costs has particular relevance to the pricing of electricity. The question is what pricing-strategy to employ when all external costs have not been internalized.

Some have proposed that the primary objective of pricing should be environmental protection. To meet this objective, they propose placing a tax[28] or quasi-tax, on each unit of production equal to the external damages entailed by producing it. The price would then equal the marginal private cost plus the quasi-tax, or, for electricity, the marginal social cost of producing an additional kilowatt-hour. This is known as the alternative of shadow pricing, where the tax equals the external costs associated with producing an additional kilowatt-hour.[29]

The rationale for such a method of pricing is clear. Proponents of a pollution tax, or shadow pricing, claim that market prices reflecting private costs only are too low, and lead to an over-allocation of resources to producing the good, insofar as demand is sensitive to price. Furthermore, techniques of production may be technologically inefficient. A fully efficient pricing-scheme would reflect marginal social costs, and not just marginal private costs. Efficient prices, then, would be higher, and output lower, if price equalled marginal social cost.

Such a pricing policy is not without precedent, and the National Energy Board has implicitly endorsed shadow pricing for Ontario Hydro. Furthermore, such a pricing-policy fits in well with economic theory. The requirements of economic efficiency dictate a tax or "shadow price" upon the production activities of the generator of an externality. If such a tax were equal to the marginal net damage caused by producing electricity, the price would equal marginal social cost. The customer would then face a price which represented the real resource cost consequences of consuming one more kilowatt-hour, or one less.[30]

2. The Case Against Shadow Pricing

A strong case can thus be made for the shadow pricing of the external costs associated with the production of electricity. but such a pricing policy is not without drawbacks. There are at

---

[25]See Volume 5 for the full development of and rationale for marginal-cost pricing.

[26]The net-benefit criterion is also known as the "Pareto criterion", in recognition of the work of the economist Vilfredo Pareto, who first developed it. Economic efficiency, or Pareto optimality, is a well known principle of welfare economics. The basic idea is that a situation is inefficient (or 'non-optimal') in production and/or exchange if it is possible to make at least one person better off without making any other member of society worse off. In other words, a situation is economically efficient or optimal if it is impossible to make anyone better off without at the same time making someone else worse off in production and/or exchange. It is worthwhile pointing out that this criterion of efficiency need not lead to the unambiguous ordering of alternatives, since theoretically there exists an infinity of positions which are economically efficient or Pareto optimal.

[27]See, for example, E.J. Mishan, *The Costs of Economic Growth*, (Penguin Books, 1967), p. 82-87

[28]An externality tax and a shadow price produce the same results analytically, since in theory both should be equal to marginal net damage. In practice, an externality tax would be placed on the utility's output by some outside body. A shadow price would represent the utility's own decision.

[29]"Shadow pricing" refers to the adjustment of market prices to allow for considerations they would not otherwise reflect For a fuller discussion see J. Margolis, "Shadow Prices for Incorrect or Non-existent Market Values", in *Public Expenditures and Policy Analy*, ed. R.H. Haverman and J. Margolis, (Chicago, 1970) pp. 314-329

[30]See, for example, Baumol and Oates, p. 54.

least seven important difficulties with such a proposal, and these are discussed below.

2. Information Requirements

As was indicated, the proper level of tax on each kilowatt-hour equals the marginal net damage, or benefit, that results from producing electricity. It is enormously difficult to obtain a reasonable estimate of the money value of this marginal damage. Furthermore, considerable resources would be needed to develop a comprehensive body of statistics reporting this damage. The number of parties involved, and the complex interdependencies among them, make the task a monumental one. Add to this the fact that many of the most important consequences the damage to health, and (for example,) aesthetic costs, (cannot be quantified,) and the difficulty of determining a money equivalent for marginal net damage becomes quite apparent.

b. Specification of An Optimal Tax Level[31]

The optimal tax level on an activity that generates an externality is not equal to the marginal net damage it causes initially, but rather to the damage it would cause if the level of the activity had been adjusted to its optimum. Consider an example: suppose that each additional unit of output of a factory now causes damage worth fifty cents, but after installing the appropriate smoke-control devices, the marginal social damage would be reduced to twenty cents. A tax of fifty cents per unit of output corresponding to the current smoke damage would lead to an excessive reduction in the smoke-producing activity, a reduction beyond the range over which the marginal benefit of decreasing smoke emission exceeds its marginal cost.

The relevance of this point is that it compounds enormously the difficulty of determining the optimal levels of tax and benefit. If there is considerable difficulty in estimating the damage that is being done now, how unlikely it is that estimates could be made of the damage that would occur in an optimal world situation, not yet experienced, or even described in quantitative terms.

One alternative route to the optimal solution may prove more practical. Instead of adopting the optimal tax policy, immediately, one could first base a set of taxes, or shadow prices, on the current net damage levels. As outputs and damage levels were modified in response to the level of taxes, the taxes themselves could be adjusted to correspond to the new damage levels. One might hope this would become a spiral, with tax levels affecting outputs and damages, which would, in turn, lead to modifications in taxes and so on.

Unfortunately, such a spiral also requires information that is hard to acquire. At each point in the sequence, one must be able to evaluate what the preceding step has achieved, and how to effect further improvement. But neither the relevant costs nor the incremental damages corresponding to each conceivable step can be calculated. Thus, there seems to be no way to obtain the information needed to implement the tax, shadow-price, approach to the control of externalities.

c. Input Substitute and Change Ratios of Pollution to Output[32]

A tax or shadow price on each kilowatt-hour might lead to a socially inefficient result if applied to different production techniques with different ratios of pollution to output. Obviously, Ontario Hydro has many production techniques available with different ratios of output to pollution. In such a case as this, externality taxes or shadow prices per kilowatt-hour will yield prices that are too high, output that is too low, and a socially inefficient production technique.

Consider the following example. Electricity can be produced by two constant returns to scale production techniques, A and B. Technique A would produce one kilowatt-hour of electricity and one lungfull of smoke, for a total private cost of 10 cents. Technique B would produce one kilowatt-hour of electricity and no smoke, for a total private cost of 12 cents. The external cost of a lung full of smoke is 5 cents. Without pollution taxes, or shadow pricing, the firm would employ technique A. With taxes or shadow prices of 5 cents per kilowatt-hour, set directly on output, the firm would continue to generate electricity with technique A, charging a price of 15 cents per kilowatt-hour, before profits. It would not use technique B because it would still have to pay the externality taxes which are set on output, and its costs would be 17 cents per kilowatt-hour.

In such a case, externality taxes or shadow prices are clearly inefficient. A superior approach would be pollution taxes on smoke, which would encourage our hypothetical firm to use technology B. The price would now be 12 cents per kilowatt-hour, and there would be no pollution.

d. Excess Revenue

If shadow pricing is employed, then there arises a problem concerning excess revenue. The easiest and most obvious method is that recommended in Volume eight on pricing: adjust the customer charge downward.

The compensation of the victims of the externalities must be ruled out, because of the possibility of misallocating resources. This is due to the undepletable characteristics of environmental pollution, the source of the externalities under consideration. Smoke, for example, is an undepletable externality. The fact that Mr Jones's house is enveloped by smoke does not, in general, either reduce or increase the damage to his neighbour. How would some misallocation result if Mr Jones and his neighbour were both to receive compensation to cover their loss? In this case, an optimal solution generally requires some degree of geographic separation between smoky factories and private residences. If all neighbours of factories were paid amounts sufficient to compensate them fully, not only for the unpleasantness but also for such things as their increased laundry bills and the damage to their health, then no one would have an obvious motivation to live away from the factory. Too many persons would choose to live in smoky conditions; for they would, in effect, have been offered an economic incentive to accept the ill effects of smoke, with no off-setting benefits to anyone. The resulting inefficiency is clear enough.[33]

e. Geographic Dispersion of External Costs

One assumption in the traditional case for shadow pricing or an externality tax is that there is a direct and additive relationship between the emission of pollutants and the loss of welfare the community suffers. However, that is not always so; for example, a firm that emits waste into the upper parts of a river may do more or less damage to the community than one that discharges the same amount of effluent downstream. The upstream emissions may be less damaging than those downstream if the upper

[31]This analysis is taken from Baumol and Oates, pp. 136-37

[32]This analysis of changing output-pollution ratios is taken from Joskow, pp. 37-38

[33]For further discussion of this issue of compensation, see Baumol and Oates, pp 25 and 31.

part of the river is sufficiently unpolluted to permit natural processes to disperse or degrade a considerable share of the wastes before they affect anyone. On the other hand, if there is little natural action on the effluent, it may well be more costly to society than discharges into the lower parts of the river, because people and activities along the whole length of the river may be affected by the pollution which originated upstream.

Because the social damage caused by pollution upstream and downstream varies, it is not appropriate to shadow-price or tax output at the same rate. Indeed, correct shadow-pricing would have to work on a geographical basis, and it is impossible to obtain the information required to determine differential shadow prices.

f. Random Nature of Some External Costs

In some cases, the damage done by an emission depends almost exclusively on how big it is and on how many people are vulnerable to its effects because of where they are. The annoyance of a loud noise may plausibly be considered to depend largely on its loudness and on the number of persons within earshot.

However, under many other circumstances, the external costs of a particular activity depend on variables beyond the control of those directly involved. For example, the polluting effects of a given discharge of effluent into a river will depend on the condition of the waterway at that time, whether (for instance) it has just been filled up by a rainfall or depleted by a drought. The amount of water and the speed of its flow are critical in determining the capacity of the river to assimilate pollution. Similarly, if there is any wind, its direction and velocity will affect the level of pollution in the air and its consequent effects.

The point of all this is that levels of pollution that are acceptable and rather harmless under usual conditions can, under other circumstances, become intolerable. Moreover, these conditions depend on the values of variables that are not in the control of the person making the decision. Often they are not predictable much in advance. Weather, for example, must, for most purposes, be considered largely exogenous and only imperfectly foreseeable.

There is virtually no way to deal with such variations in establishing a shadow price or externality tax.

Inflexibility

One drawback to a shadow-pricing scheme has been implicit throughout the above analysis: its lack of flexibility. Shadow prices would be hard to change on short notice, or implement on a regional basis. They cannot allow for differences in the effects of the emission of equal amounts of pollutants. Such inflexibility makes shadow pricing a questionable tool for dealing with the external costs of producing electricity. Given the above analysis, it is recommended that

> ***Shadow pricing or an externality tax should be rejected as an alternative for pricing-policy. The Corporation should base its prices on marginal private costs, while meeting the prescribed environmental standards set by the government.***

In meeting prescribed standards of, course, external costs are internalized. After internalization is achieved, the Corporation would consider all the costs it was about to incur in setting prices based on marginal costs.

There are also effective alternatives to shadow pricing: prescribed air-quality standards, emission standards, pollution charges, and direct control, to name the main ones. Some degree of arbitrariness in the design of such standards is inevitable, and, the use of such standards will never result in optimality in the theoretical sense. To follow this alternative is essentially a 'satisficing'[34] approach to the problem, yet it does offer some significant optimality properties.[35] Besides administrative savings and relative ease, the above measures, if properly designed and implemented, could lead to the attainment of the selected standards at something like minimum cost to society.

There are further advantages which make standards and control a superior alternative to shadow pricing at present. Pollution charges and standards do not require the calculation of the effects of pollution on health, or on the pleasure one takes in one's surroundings, nor the conversion of these into common money units. For example, pollution charges could be chosen to achieve specific acceptability standards rather than the unknown value of marginal net damages.

Pollution charges, standards, and controls are flexible. They can be differentiated by region. Direct controls are easily invoked in emergency situations.

Thus to arrive at the socially desirable level of internalization of external costs, it is suggested that some combination of pollution charges, standards and controls should be employed. It is beyond the scope of the Electricity Costing and Pricing Study to establish the appropriate combination of the above measures, the desired level of internalization of external costs, or even the criteria to follow in undertaking the task.

C. THE MEASUREMENT OF EXTERNAL COSTS: AN OVERVIEW

As was said in the previous chapter, the most difficult problem with external costs is measuring them. However, some progress has been made with that, as can be seen in Ontario Hydro's 1976 submissions to the National Energy Board. For example, quantitative estimates of the external costs associated with atmospheric emissions from stations fired by oil and coal developed and submitted to the NEB. It is reasonable to expect that measures of external costs will continue to improve. The purpose of this chapter is not to review these past studies, but rather to provide an overview of both the problem of measurement and current techniques.

1. The Problem of Measurement

It is useful to identify all aspects of man's environment on which Ontario Hydro's production activities may have an external effect. Five general categories can be identified:

1. Air and the life it supports,
2. Water and the life it supports,
3. Land and the life it supports,
4. Any combination of these, and
5. Man's enjoyment of these (i.e. aesthetics).

---

[34]That is, there is no attempt to seek any sort of optimum. Rather, one merely seeks policies capable of meeting some present standards. and, so, of producing results considered satisfactory The term 'satisficing' was coined by Herbert Simon.

[35]This 'satisficing' approach is the policy direction recommended by Baumol and Oates, pp 129-171.

For each of these categories, estimates of the external costs or benefits associated with producing electricity have to be developed. This requires three steps:

1. Identifying and tracing a causal relationship between production activities and external effects;
2. Estimating these effects, quantitatively if possible, and qualitatively otherwise; and
3. Assigning a dollar value to these external effects.

2. Measuring Techniques

While the necessary steps are well defined, the actual measuring-procedures are not. There is no single methodology which one can employ to measure external costs. Given the current state of the art, the following three methodologies can be used to derive external cost estimates:

a. Engineering approach (technical co-efficients of production and consumption);
b. Market studies approach; and
c. Opinion surveys approach.

a. Engineering Approach

The engineering approach is also called the technical co-efficients approach. This is a method used in studying the social effects of air pollution on textiles, buildings, water quality, vegetation, and animal life and health. In general, the method follows these steps:

1. Experimental data are gathered by observing objects in conditions simulating their natural environment. This step yields 'control group' data.
2. An external-effect function is developed which relates damage to different pollution levels. This is the stage at which threshold levels, or relative severity factors, are established. Basically a threshold tolerance level is a level above which some kind of damage is expected. These levels are modified by considerations of what is economical and feasible. The standards upon which the threshold levels are based may apply not only to the average concentrations of various pollutants in the environment, but also to the frequency and duration when concentrations may exceed certain permissable levels.
3. The external-effect function is then translated into economic terms (unit costs).
4. These unit costs must then be extrapolated to the population in order to arrive at an estimate of total external costs.

There are important drawbacks to this approach. First, there is the problem of extrapolating from controlled research environments to conditions in the real world. The long-range effect of various ambient concentrations of sulphur dioxide on the breaking-strength of cotton fabric provides an example of this. The effect of a significant increase in the sulphur-dioxide level is dramatic. However, there is no cumulative effect from the build-up of sulphur dioxide with prolonged exposure, since cotton fabrics are frequently washed. Furthermore, social-effect data on textiles have to be carefully qualified by taking temperature, humidity, and sunlight into account. Changes in these variables often have a more significant effect on fabric deterioration than measurable changes in levels of pollution.

The second problem lies in how to develop figures for unit and total external costs. Continuing the textile example, conclusive evidence to show that increased particulate levels affect the frequency of cleaning household furnishings over their useful life is not available. Studies are even less conclusive regarding clothing. This is due to other factors, such as habit and style obsolescence, which could well predominate over cleaning garments, or throwing them away, because of pollution. Because of considerations such as these, the aggregate social effects cannot be treated as the simple arithmetic sum of individual effects even with these limitations, this is the method that has been most widely used to date.

b. Market Studies

The market studies approach attempts to measure social costs by consulting market information. The consideration here is the effect of the level of air pollution on human behaviour as reflected in markets. This approach eliminates the need to know the relationship between various doses of pollution and the corresponding responses. Statistical and econometric techniques are applied to market data to isolate the adverse effect of air pollution on a particular activity in the market place.

One type of market study, for example, is the use of property values to estimate damages from air pollution. A significant feature of air pollution is its restriction to one place. Since people are willing to pay to avoid the effects of air pollution, property values and air pollution concentrations must vary inversely.

Multiple regression analysis is used in most studies to establish a relationship between property values in a chosen cross-section of a metropolitan area and the level of one or more pollutants there. This method would yield accurate results only if the real-estate market were 'perfect'. This would imply that house buyers knew the level of air pollution in each part of the metropolitan area and also the effects of different levels of air pollution on, for example, health, and maintenance costs. This is not normally so.

Another problem is the high degree of correlation between two pollution measures. IN REGRESSION ANALYSIs this is known as collinearity. Pollution tends to be a composite phenomenon, and the presence of one pollutant is usually a reliable indicator that others are present. This difficulty contributes to the theoretical and practical problems and uncertainties surrounding regression-based real-property studies.

If a meaningful measure were established for damage to property values from air pollution, this would in theory have to include the capitalized cost of such things as repainting and laundering. It is hard to calculate the overlap of damage estimates in these special areas, and thus remove twice-counted items from total damages from air pollution.

c. Opinion Surveys Approach

It is appropriate for those who have responsibility in making decisions about environmental standards to be concerned about public opinion. Indeed, this approach is closest to the classical economic approach, in that it focuses on estimating utility and demand functions.

There are, however, two major problems in conducting opinion surveys. First there is the problem of eliciting complete information from people in a way that will dissuade false responses. Secondly, there is the possibility that a respondent might not fully understand the consequences of air pollution, on his health for example. In spite of these problems, opinion surveys have shown particular usefulness in understanding the following:

1. How attitudes about different forms of pollution are formed, and are then affected by changes in the quality of the environment;

2. What people do and do not perceive as effects of pollution; and

3. Some insight into what people may be willing to pay for improvement in the environment.

SUMMARY OF MAIN RECOMMENDATIONS

A. Definitions

1. *Externality.* An externality is present whenever some individual's (say A's) utility or production relationships include real (that is, non-monetary) variables, whose values are chosen by others (persons, corporations, governments) without particular attention to the effects on A's welfare.

2. *Social Cost.* Total Social Cost = Private Cost + External Cost, where

   a. Total social cost refers to the total economic cost generated by the production and market activity of a particular entity,

   b. Private cost refers to those costs faced by and internal to the economic decision unit, and

   c. External cost refers to the money value of the externalities caused by the production and market activity of a particular economic decision unit upon those persons or decision units who are external to the producing unit's decision-making process and market activity.

B. Shadow Pricing

Shadow pricing, or an externality tax, should be rejected as an alternative for pricing-policy. The corporation should base its prices on marginal private costs, while meeting the prescribed environmental standards set by the government.

Studies should be undertaken to consider the following areas:

1. The development of criteria by which the appropriate level of environmental standards (direct controls, charges, etc.) may be assessed.

2. The development of measurement techniques to evaluate the external costs and benefits associated with producing electricity.

APPENDIX I: Fully-Distributed Average-Cost Pricing in Ontario

The current basis for pricing electricity in Ontario is essentially a fully-distributed-cost system (FDC), which employs several kinds of cost averaging. Aspects of incremental cost are also considered in establishing the rate structures.

The goal of fully distributed costing, in itself, is to allocate the revenue requirement for the year when the rates are to apply among all customers taking service. Since the revenue requirement is always constrained to the total costs of the period, as defined by accepted accounting-procedures, all customers will, taken together, pay the cost of the service provided.

In meeting its objectives for ratemaking, Ontario Hydro and its associated municipalities have in the past sought to minimize any undesirable cross-subsidy between customers. On a conceptual level, it follows that each customer, depending on his specific requirements, will bear his own cost of service through the rates charged. Thus as a matter of course, the revenue requirement will always be met.

A. THE OBJECTIVES

1. Lowest Feasible Cost to the Customer

Ontario Hydro's corporate objective requires it to provide good service at the lowest feasible cost. There are several facets to this objective:

1. It entails trying to ensure that all costs are minimized in providing good electrical service. For example, rates could be raised to yield more equity, but should not be raised more than is needed to maintain a good credit rating.
2. The rate system should encourage using the power system efficiently. Examples of ways that is now done are interruptible and scheduled power rates and the use of demand features.
3. The rate system should not encourage using society's resources inefficiently, even though the power system itself may be producing efficiently. For example, demand charges should not be so high that it encourages the customer to install small, inefficient generating-plants to shave peak, nor should it be so low that it encourages inordinately high demands.
4. The rate system should be easy enough to administer that the administrative costs not exceed the benefits of the complexities.

2. A Fair Distribution of Cost to the Customer

The following discussion of a fair allocation or distribution of cost is in the context of the traditional perspective. Good service to customers requires treating both classes of customers and individual customers fairly. In a strict sense, distributing costs to customers fairly would require a different rate for every customer, since the costs of serving each customer are different. In practice, that is not possible; and if it were, it would be extremely costly and therefore conflict with the preceding objective of low cost.

Distributing costs fairly to the customers has many implications, some of which are these:

1. The rate system must be based on the costs of service, rather than set artificially to achieve what the utility considers to be desirable social goals, or objectives of management that may conflict with the needs of the community.
2. Customers with like characteristics must be charged the same price: that is, there must be no undue discrimination.
3. Only those customers actually using a part of the system should have to pay for that part. For example, only customers using the distributing-system should pay its costs.
4. All customers have a vested interest in the system, and should therefore share in the system's historical benefits of investment. There should be no seniority among customers.
5. The way the rate structure allocates the demand costs should reflect the contribution of all customers to diversity. All customers contribute to the diversity of the system, and therefore to the savings from not having to meet all demands at once.
6. A change in the characteristics of one customer or group of customers should not result in an unreasonable change in the price the remaining customers pay.
   Under changing conditions (such as rapid inflation), not all implications of a fair distribution of costs are compatible. Instead one must formulate the tradeoffs and apply judgement to effect the best possible compromise.

3. Simplicity

Generally speaking, the decision by the customer to purchase energy is complementary, resulting from a decision to purchase an energy-consuming good. If the customer is to take account in his decision of the cost of energy which this purchase will involve, the rate system must be simple enough for him to understand its implications.

4. Impacts Rate structures continually develop over time. Changes result from changing patterns of customer load and system costs, and a changing environment. If rate structures were to change abruptly many customers who had previously invested in durable goods would suffer hardship. It is therefore desirable to phase in changes over a period of time, to minimize the hardship which rate instability would inflict. Furthermore, in order to avoid undue effects from a change in use, the rate structure itself should not contain any abrupt discontinuities.

B. CONCEPTUAL DEVELOPMENT

The two prominent factors in most operating-costs are energy production and system capacity (rate of energy production). The cost related to energy production is mostly variable, including fuel, operating-costs and the share of plant associated with producing energy. However, the cost associated with system capacity is usually fixed in the short run but related to the maximum demand on system capacity over time.

Maximum system demand is in turn related to the demands of all customers and how these coincide at any particular point in time. Depending on the time of peak demand, each customer may contribute anywhere from zero to his own maximum demand to the maximum system demand. Generally, the maximum system demand and the sum of all maximum non-coincident demands differ because of the diversity among customers.

All ratemakers recognize the customers' requirements for energy and system capacity (rate of energy use) for purposes of pricing, because of their strong influence on cost. Before discussing the treatment of these two factors, it is worthwhile to note other cost factors which receive varying degrees of recognition, depending on their overall significance and on the ratemaking philosophy.

For example, a small share of utility cost is independent of energy use and closely associated with the facilities and activities required to make service available on an ongoing basis, such as the costs of service conductors, meters, meter reading, and billing. One can link these direct customer costs expressly with each individual customer, and the total cost with the number of customers served. Customer costs are more or less uniform over all customers, or at least for large groups of similar customers, though they may vary between new and old customers because of inflation.

Direct customer costs, and the need to provide a basic distributing-system to meet minimal energy use, have led ratemakers traditionally to use declining-block rates with higher initial charges to the customer. As fixed costs are recovered in the initial blocks, the price declines to the average cost of providing more electricity. However, in recent years the variable cost has risen, particularly the bulk-power component, tending to flatten the declining rate. In the past explicit use of customer costs has been limited to calculating a minimum bill.

The geographic dispersion of the delivery system can and does affect the cost of providing service as well. Given two customers equal in every other way, it costs less to serve the one nearer to a load centre than one further away. However, having both together yields offsetting mutual benefits, such as benefits of scale, diversity, quality, and reliability of supply. Ontario Hydro has therefore adopted the concept of "cost pooling" for all but extreme cases of cost differentials arising from geographic dispersion. In this way all customers, as co-operative members, share in the advantages of a large integrated system.

While in some ways it might seem fairer to determine each customer's service costs exactly, this proposition would conflict with the objectives of low administrative costs and simple rates. Since costs related to capacity reflect the cost of supplying many customers, probably with vastly different demand characteristics, it would be virtually impossible to determine the exact cost of service for every customer.

The rate for energy (in kilowatt-hours) may therefore be set at the variable cost of energy as previously defined, and the rate for demand in system capacity (in kilowatts) may be based on system capacity costs incurred over time, for groups of customers (classes) with similar demand characteristics. As the grouping-process would imply, costs have been averaged, in order to simplify rate structures and minimize metering-costs, as well as to distribute costs fairly.

At present the fully distributed average-cost system attempts to be fair, and at the same time is less expensive and administratively more attractive than other methods of costing and pricing. Since costs are averaged over time and output, it involves a minimum of administrative cost, and the rate structures are therefore fairly straightforward. On the other hand, the price signals are based on historical costs.

C. THE RATE SCHEDULES

The pricing-format below is the general structure of rates Ontario Hydro now employs. It has developed gradually from the single customer charge used in the very early days of pricing electricity.

1. The Wholesale Schedule

The wholesale rate schedule has two parts, a rate for energy and a rate for monthly non-coincident maximum demand. The demand rate includes the cost of wholesale facilities common to all municipal utilities,plus, where appropriate, the cost of any specific non-common facilities Ontario Hydro provides to a municipal utility.

2. The Retail Schedule

a. The 'Large-User' Rate

This schedule applies to all retail customers with a billing-demand of more than 5,000 kilowatts, and has two-part rates similar to those of the wholesale schedule.

b. The 'General-Service' Rate

This schedule applies to all customers taking less than 5000 kW except residential customers, and has a multi-component structure utilizing both blocked demand, and blocked energy rates, plus a minimum bill. There are usually five energy blocks, the first three being the first 50 kilowatt-hours per month, then the next 200, and then the next 9,750. The fourth block varies, in size to achieve a smooth transition between the general service rate and the large user rate at 5000 kilowatts. The fifth or remaining block is unlimited and priced at the energy rate for large users. There are also two demand blocks: the first 50 kW per month, at no charge, and the rest of the billing-demand. Billing-demand is defined as the maximum monthly non-coincident demand in kilowatts, modified by a power-factor penalty if necessary.

c. The Residential Schedule

This schedule uses only a blocked energy structure and a minimum bill. There are generally three energy blocks consisting of the first 50 kilowatt-hours per month, the next 200 kilowatt-hours, and any remainder. Customers with electric water-heaters have a further block of 500 kilowatt-hours inserted into the structure following the second block. This accommodated the special load characteristics of electric water-heaters, and was priced accordingly. Since the advantages of uncontrolled water-heating are diminishing, the practice is being continued for controlled water-heaters only.

D. PRICING-METHODOLOGY

The present pricing-procedure involves two steps: allocating the costs of the bulk-power system to wholesale customers (each municipal utility and the Ontario Hydro Power District), and setting retail rates to yield enough revenue to meet these costs of the bulk-power system and also the local costs of each retail utility.

The basis of the wholesale allocation is reviewed here as background for reviewing the current method of setting retail rates. The rationale behind the present allocating process is that each wholesale customer sharing the use of a facility should also share its cost. The amount that each customer contributes towards the cost of a facility is measured by his non-coincident monthly peak demand and his use of energy. For carrying this into practice, the costs of the bulk-power system are divided into functions, such as generation, grid, transformation, and administration, so that where a municipal utility does not use Ontario Hydro transformation (for example) it would not have to share the costs of providing transformation. The costs totalled for each function are then allocated to each wholesale customer, using the function on a unit cost basis. For the function of generation two units are used, a cost per kilowatt of demand and a cost per kilowatt-hour of use. For most other functions, the unit is cost per kilowatt of demand only.

At the wholesale level, there are 354 customers, and the process enables Ontario Hydro to allocate costs to each of them. There are over two million retail customers, though; and allocating costs to each of them is not practical. Therefore the pricing-process for retail customers entails establishing customer classes and designing retail rates for customers in each class.

Traditionally, there have been four main classes; residential, commercial, industrial, and street lighting. Within each of these there may be two or more sub-classes, for example, small commercial and regular commercial. At times special sub-classes were established (such as all-electric residential customers) for various reasons which seemed appropriate at the time. At present the policy is to reduce the number of different classes and the number of rates applying to customers within any class. The object of this is to avoid accusations that there is undue discrimination among customers.

At the level of retail rates, the customer's ability to understand rate structures and control his load has affected design. For example, the residential customer and the smaller commercial customer have little chance, if any, to control their demand; and therefore demand charges in the structure of residential and small commercial rates do not encourage the customer to improve his load factor. Since there is already considerable natural diversity between small customers, and individually the small customer does not significantly affect the total cost of operating a utility, it has been thought acceptable to let the individual demand characteristics average out between them. Also, the cost of metering these customers for demand would be quite high. Therefore the structures for residential and small commercial rates do not contain a demand charge. The demand and energy costs are combined, based on the class load factor, and allocated to individual customers as an energy rate only. On the other hand, for customers over 50 kilowatts a separate demand charge is levied, along with a suitably lowered energy rate; and this has proved effective as an incentive to improve load factor.

In establishing retail rates, the rate for the large user (over 5,000 kilowatts) is determined first. Customers of this size have a significant effect on utility costs, in particular, the cost of power purchased; and the rate structure is therefore priced very close to the components in the wholesale rate to the utility. However, the wholesale demand rate is reduced, and the difference transferred to the energy rate, to recognize that diversity decreases as load factor increases. In this way any change in load characteristics of the large-use class will decrease or increase both the utility's revenue and its expense together, without harming its financial position.

Because the rates to residential and small commercial customers are based on class characteristics and do not contain separate demand charges, the general rate applying to both commercial and industrial customers in most municipal utilities is designed to bridge the gap between the block structure of energy rates for the small customers and the demand-energy rate structure for the large user.

In determining revenue requirements for each customer class costs are not formally allocated. To do so would normally involve allocating each item of annual expense to the demand and energy components of the customer classes. By totalling these allocated costs, one would arrive at the revenue requirement for each class. Although a formal allocation could conceivably be made for each utility, it would be extremely costly to make it acceptably accurate, considering the sheer numbers involved.

Traditionally, between customers of equal size, rates were higher for commercial customers than for residential customers; and similarly they were higher for most commercial customers than for industrial customers. Introducing the general rate, which applies to both commercial and industrial customers, removed any difference in rates between these two classes. The general rate is used in setting the flat energy rate for street lighting, and for other separately metered commercial services such as heating and cooking, thus effectively removing the need for a formal allocation process to determine revenue requirements for these individual classes.

So far, load surveys have failed to show a justification for the traditional relationship between rates for residential and non-residential customers. Lately the problem has been to reduce the traditional differential between rates for residential and for non-residential customers. Therefore the pricing of the rate structure has followed a formula designed to meet the following criteria:

1. The use of a blocked energy rate for small customers (at present less than 50 kilowatts).
2. Residential end rates at a level adequate to cover the cost of power to the utility (at wholesale rates), the costs of the distributing-system (based on engineering-studies) and losses, as well as to provide a margin towards recovering the utility's administrative costs. The utility's fixed costs (such as the basic distributing-system and administration) are recovered in higher-priced initial blocks of kilowatt hours, a practice which has so far entailed a price structure of declining blocks for energy rates.
3. Large-use rates priced in accordance with the wholesale rate, in order to allocate cost to this class fairly.
4. A structure for the general rate which provides a smooth transition from a block energy-rate structure for small customers to the demand-energy rates for the large user, while at the same time gradually reducing (in percentage) the differential between residential and commercial customers of the same size.
5. To meet, in total, the revenue requirement of the utility.

APPENDIX II: Methods of Allocating Costs[36]

This appendix will analyse 29 methods of allocating been proposed over the years, discussing the justification and shortcomings of each, eliminating some as reasonable contenders and expressing preferences among others. There will then be an attempt to group all the methods into a few categories. The range of allocation and how it can be reduced will also be handled.

1. Peak Responsibility[37]

This method allocates capacity costs in proportion to customer demands at the time of system peak. There are two ways to justify this method.

1. Capacity is constructed to meet the system peak. Off-peak uses are by-products.
2. Only added demands at the time of system peak create a need for add capacity.

To the first argument the reply is that only some capacity is constructed to meet the peak demand on the system.

If the peak on July 15 is 100 megawatts and the peak on December 15 is 99 megawatts, it is ridiculous to say that the 100 megawatts of capacity is required only for July 15. Actually,;only one megawatt is required only for July 15; the other 99 are required for both December 15 and July 15.

The second argument confuses sunk costs with future costs. The two are different in principle and purpose. The only reason for allocating sunk costs on the basis of incremental costs would be to reduce costs. That is, if demand were elastic, then rates should be set to avoid incurring added costs. Such an allocation would be made for economic reasons, not for fairness' sake.

But if so, an allocation would be the wrong way to set rates, since demand elasticities would also have to figure in rate making. Note also that in practice an element of unfairness may be involved if certain classes of peak-time demand are increasing at a faster percentage rate than others. The traditional criticism of the method of peak responsibility is that it wrongly assumes the time of peak never changes. It is usually contended (rightly) that a change in the time of the peak will completely change the allocations, so that the method leads to highly unstable allocated costs. This is not only of practical importance, but it also suggests an important theoretical weakness. The failure to allocate costs to demands when the system is not at its peak overlooks the very real possibility that such periods could become the peak, depending on how high the demand then already is compared to the system peak.

Thus the peak responsibility method is indefensible.

2. Modified Peak Responsibility

This method is attributed to W.A. Lewis. He proposed that When the morning demand reaches equality with the evening demand, and threatens to exceed it, the proper policy is to raise the morning price and lower the evening price, in an effort to keep the two peaks of equal height.[38]

In other words, one ought to allocate enough capacity cost to off-peak loads to ensure they will not exceed peak loads and so to prevent them from growing to exceed the peak.

This assumes demand elasticity, and hence is an argument on economics rather than equity. As economics it is wrong. Where demands are elastic, rates should be set on the basis of actually assignable marginal costs, rather than allocated sunk costs. Moreover, there can be no strictly economic reason for raising one rate while lowering another.

This method too, then is unacceptable.

3. Seasonal Peak Responsibility[39]

This method, attributed to A. Strickler (1928), is a modification which averages the percentage contribution of each class to a typical winter's-day peak and a typical summer's-day peak. This resembles Lewis's suggestion. (One immediately thinks also of using, not the typical winter's-day peak, but the actual winter peak.)

This ignores the relative size of the two peaks, as well as the possibility that the time of day at which the peaks occur may change over time. On the other hand, trying to allow for demands at other times besides the system peak opens a Pandora's Box of possible variants. This shows up a crucial shortcoming of the method of peak responsibility.

4. Monthly Peak Responsibility[40]

Attributed to H. Ruckwardt (1926), this method resembles No. 3; it averages the percentage contributions of each customer class to each monthly peak. This is subject to the same criticisms as No. 3, though even stronger. As with No. 3, it is impossible to justify this particular modification of the method of peak responsibility with any cost theory.

5. Class Maximum Demands

This is sometimes called the Method of Non-Coincident Peaks. It is attributed to J. Hopkinson (1892).[41] It was also once (1936) recommended by the staff of the Federal Power Commission in the United States.[42] With this method, capacity costs are allocated in proportion to the annual peak demand of each class of customers, regardless of when the peak demand of the class occurs. The obvious criticism is that the time of a demand is of great significance for determining costs. Insofar as a customer's greatest demand coincides with that of other customers, it contributes to the need for and use of extra capacity.

[36]Much of the information in the appendix has been provided to Ontario Hydro by National Economic Research Associates.

[37]This is a very old theory, referred to in most of the literature. As a technical report of the British Electrical and Allied Industries Research Association stated, 'At first sight, cost considerations would appear to load directly to the peak-responsibility method in all its starkness . . . additional equipment put in for on peak supply cannot be hired to off-peak users, because there is already far more equipment available than off-peak consumers need. The whole cost of this additional equipment must therefore fall on the on-peak consumer.' (The British Electrical and Allied Industries Research Association, *An Improved Method for Allocating to Classes of Consumers the Demand-Related Portion of the Standing Cost of Electricity Supply*, pp. 7 and 8, and the first footnote in column I of p.8).

[38]W.A. Lewis, "Overhead Costs", *The Library of Economics* (New York, 1949), p. 49.

[39]See A. Strickler: "Die Selbstkosten fur Abgabe electrischer Energie", *Bulletin SEV*, 19 (1928), p. 413. (Referred to by P. Schiller in "Critical Resume - Methods of Allocating to Classes of Consumers or Load the Demand-Related Portion of The Standing Costs of Electricity Supply", *Technical Report Reference K/T106*, British Electrical and Allied Industries Research Association (London, 1943), p. 9; also Bibliography item 31, p. 23)

[40]See H. Ruckwardt, "Methoden der Verteilung der festen Kosten", *Association of German Electricity Supply Undertakings*, 1926. (Referred to by Schiller, p. 9; also Bibliography item 24, p. 22).

[41]In 1892, Hopkinson advanced the general theory that capacity costs should be pro-rated in proportion to maximum demands or installed loads. See J. Hopkinson, "The cost of Electric Supply" (address to the Junior Society of Engineers), *Electrician* 30 (1892), p. 29. (First published in *Transactions* of the Society, later reprinted in Hopkinson's *Original Papers*, Vol. I. See also A. B. W. Kennedy, "The Hopkinson Method of Charging for Current", *Electrician* 39, p. 136, and Arthur Wright "Cost of Electrical Supply", *Proceedings of the Municipal Electric Association*, (1896), p. 44.

[42] "National Power Survey, Cost of Distribution of Electricity", *FPC Power Series* No 3 (1936), pp. 42-48. Bary used this method in a rate case of Philadelphia Electric (Docket C-15763), and Consolidated Edison and the staff of the New York Public Service Commission used a variant of it in their rate case.

Commonwealth Edison cites the following defence of the method by one H.A. Snow: "diversity is the result of a mutual relationship and is not the property of one class of service"[43]
But if the entire system had a load factor of 100 per cent, the Method of Non-Coincident Peaks would allocate more to customers with low load factors than to ones with higher ones in contradiction to the supposed principle. However, the principle itself is not too meaningful. If we turn it inside out, and say that coincidence is a mutual relationship, we can meaningfully conclude that (1) the costs of coincidence must be borne in common, (2) there are costs of coincidence, (3) it is a relationship into which not everyone enters.

For the sake of completeness, one should consider the argument that each class of service ought to bear joint costs in proportion to what it would cost to serve it separately. Like relative cost as applied to gas production, this ignores the relative contributions each customer or product class makes to the economics of joint production. (Relative cost as applied to gas production ignores that the gas lifts the oil, not the other way round; in the electric business an off-peak demand simply is not as costly to serve as the same demand at the time of the peak.)

One final criticism is that the results of applying the Method will depend, curiously enough, on how the customer classes are defined. If a customer class is subdivided into two, the sum of the costs allocated to the two classes will be greater than the costs allocated if they were treated as one, unless the two sub-classes peak at the same time. Thus so far as there is diversity of load within a class, that class tends to benefit. But the classes are then artificially defined[44]
and the door is opened to such redefinitions as will tend to allocate in the most 'desirable' way.[45]
The discrepancy between the costs allocated to individual customers taken separately and those allocated to them as a group cannot be justified, and exposes the illogicality and arbitrariness of the method.

6. Average of Class and Peak Maximum Demands[46]

This method, attributed to F. Punga (1931)[47]
averages the customer's demand at the time of system peak and at the time of his own peak, using this average as the basis for allocating costs among customers. The method combines methods 1 and 5; it appears to give results somewhere between the two, but not an average of them.

This appears to be a modification of the Method of Non-Coincident Peaks in the right direction, since it gives some recognition to the customer's contribution to the system peak, or in other words, to the timing of the customer's demand. Whether this method also represents an improvement over the Method of Peak Responsibility is another matter. It does somewhat reduce the instability of allocations inherent in that method, although considerable instability remains.[48]
No theoretical defence of this method has been constructed, nor can it be see how one could be; it appears to be another makeshift and arbitrary adjustment of an earlier method. It is a case where two wrongs do not make a right but do mitigate one another.

7. Peak Responsibility with Sharing of Maximum Demand

This method is attributed to E. Schiff (1925)[49]
and is sometimes called the Schiff Method. The calculation works somewhat as follows. Suppose the demands of all customers were completely non-coincident, so that each class has its maximum demand at a time when all other classes had zero demand. Assuming customers A, B, and C had respective peaks of ten megawatts, eight megawatts, and six megawatts, the capacity would then be allocated as follows: The top two megawatts would only be used by A and would be allocated only to A. The next two megawatts (between six and eight) would be used by both A and B, and would be allocated equally to both. The bottom six megawatts would be used by all three customers, and would be allocated equally among them.[50] The final allocations would be: $A=2+(2/2)+(6/3)=5$; $B=(2/2)+(6/3)=3$; $C=6/3=2$. $A+B+C=10=$ the system's peak.

Thus in this first step there is an allocation of costs in a hypothetical system in which customer demands are noncoincident. The second step involves comparing these allocated costs, for each customer, with the costs that would be allocated using Peak Responsibility Costs are then allocated among customers essentially on the basis of which is the larger of these two allocations for each customer. (There is a third step in which certain adjustments are made, but the practical effect is not very great.)

The results of this method appear not to vary greatly from those of Peak Responsibility. It is obviously a way of combining Methods 1 and 5, and suffers from most of their faults. The underlying rationale is stated as follows in the Commonwealth Edison brief:

> *considering each class of service, the system must be ready to serve the highest class as well as to serve the system peak load.*

This is not too coherent. Perhaps a better way of to justify this, as well as other combinations of Methods 1 and 5, would be to argue that such combinations do recognize that some customers with low demands at the time of system peak nevertheless have demands at other times great enough to justify allocating capacity costs to them; for even if there were no coincidence great enough to create a system peak, significant capacity would still be needed to serve these large customer peaks. Thus these methods give some weight to use of capacity at off-peak times. However, they give no weight to the timing, and hence the coincidence, of these off-peak demands. There are more

[43] "Overhead expense and fixed charges cannot be definitely and indisputably assigned but must be prorated on some more or less arbitrary basis....(Thus) overhead costs and fixed charges are prorated in proportion to the demands of the several classes of service irrespective of the time of the occurrence of the class demand." H.A. Snow, Statistician (later Comptroller), Detroit Edison Company, "Sharing Benefits of Diversity in Loads", *Electrical World*, 87 (1926) p. 404. See also A.S. Knight, "Peak Responsibility As The Basis For Allocating Fixed Costs", 87 (1926), p. 496: "The fixed production cost of each class should ... be figured on the maximum demand of the class itself and not upon the demand which happens to occur at peak time only, because the former represents the capacity that must be available when needed to serve this business."
[44] The definition is artificial because it ignores load characteristics, which from the operating-standpoint are the only identifying characteristics of customers. The classification of the customer depends on who he is rather than what he is.
[45] In practical terms, it is known that small commercial customers tend to have peak demand (in the winter) at a different time from large commercial customers. Thus, breaking up the commercial class into two sub-classes will increase the costs allocated to commercial customers as a whole.
[46] Discussed in detail (with embellishments) by F. Punga in "Die verteilung der donstanten Kosten auf die einzelnen Abnehmer eines Elektrizitatswerkes", *ETZ* 52 (January 1931), p. 9. Also H. Sihle, "Zur Frage der Verteilung der konstanten Kosten eines Elektrizitatswerkes", *ETZ* 53 (1932), p. 555.
[47] NARUC refers to it as the Punga Method.
[48] In practice the results seem to be closer to 5 than to 1.
[49] E. Schiff, "Verteilung der Leistungskosten elektricher Arbeit", *ETZ* 46 (1925), p. 758.
[50] This method has formal simularities to the Method of Distributed Responsibility, to be discussed below.

appropriate and less arbitrary ways to give off-peak demands some weight, as will be shown later.

8. The Weighted-Peak Method[51]

This is attributed to C.S. Reed (1927), and may be the best method discussed thus far. It too is a combination of Methods 1 and 5, but it avoids at least some of the criticisms applying to such combinations. Basically it is a variant of Method 6. While in 6 the customer's own peak demand is added to his demand at the system peak, in this method the customer's peak demand is first multiplied by the ratio of the system demand at the time of the system peak. This takes account of when the customer has his peak demand: the higher the system demand at the time of the customer's peak demand, the more is allocated to that customer.

In practice, this method seems to give quite similar results to Method 5, except that it tends to give a substantial break to customers who do not contribute much to the system peak and whose own peak demand occurs when system demand is relatively low: in other words, truly off-peak customers are allocated less costs than by the Method of Non-Coincident Peaks. Despite the apparent similarity between this and 1, the resulting allocations are much closer to those of 5; in particular, a shift in the time of the system peak affects the allocation only slightly. The method also tends to reduce the allocation to customers with relatively low demand at the time of the system peak. One final advantage is that the method requires comparatively little load data, considering the range of factors to which it gives weight.

One obvious disadvantage of the method is that it is essentially based on an arbitrary formula, the coefficients and form of which could equally well be somewhat different. There is no underlying rationale which leads directly to this formula and no other. It is easy to think of equally reasonable variants which would allocate quite differently, especially to off-peak customers. An important theoretical flaw of this method is that, as with both 1 and 5, its failure to consider anything besides single peaks, whether the customer's or the system's But usually electrical utility systems have many sub-peaks of no small importance[52]
; moreover, the trend is for such sub-peaks to proliferate. The theoretical significance of these sub-peaks, and indeed of the whole load pattern of the system and each customer's contribution to it, will be developed later in the discussion of the Method of Distributed Responsibility.

9. The Method of Distributed Responsibility[53]

The method was first proposed by P. Lauriol in 1902, and H.E. Eisenmenger advocated a highly similar version a book first published in the U.S. in 1921. Other credited proponents are M. Schwabach (1903) and R. Arbeiter (1914). The method was also developed independently by W.E. Eggleston of Commonwealth Edison in 1946. There are numerous variants.

The basic rationale is that each customer ought to bear the cost of just that share of the capacity which he uses. At first glance this would seem to imply an allocation in proportion to kilowatt-hours consumed; but the following illustration will show this is not so. The illustration should also lay bare the rationale of the method.

Assume a system with two customers, A and B. It only operates during two hours, I and II. During hour I, A is the only customer; he has ten kilowatts of demand and consumes ten kilowatt-hours. During II, B is the only customer; his demand is six kilowatts and he consumes 6 kilowatt-hours. The system's capacity is just enough to serve a ten-kilowatt demand.

The allocation of the system's capacity cost would proceed as follows. There are four kilowatts of capacity which only A uses. Therefore, only A ought to bear their cost. The other six kilowatts of capacity are used by both A and B for equal lengths of time. Therefore the cost of those six kilowatts ought to be shared equally by A and B. Thus A has allocated to him a total of seven kilowatts (4+6/2), and B has allocated to him a total of three kilowatts. Note that A must bear 70 per cent of the costs, although he only accounts for 62.5 per cent (10/16) of the kilowatt-hours consumed. (A's capacity cost per kilowatt-hour will be 40 per cent greater than B's.)

One feature of the method that the preceding example does not bring out is that the costs are first allocated among time periods and then among customers in each period. The accompanying example will show this.

Customer	Demand (kW) Hour I	Hour II
A	9	1
B	1	5
Total	10	6

As before, seven kilowatts are allocated to Hour I and three to Hour II. Of the seven kilowatts allocated to Hour I, 90 per cent, or 6.3 kilowatts, is allocated to A. Of the three kilowatts allocated to Hour II, one sixth, or 0.5 kilowatts, is allocated to A. Thus the share allocated to A is 6.8 kilowatts, or 68 per cent of the total.

This method takes full account of all characteristics of customer and system loads.[54] The capacity it charges exclusively to peak-time customers is just that capacity which is used only at the time of the peak; in other words, the customers at peak bear the sole responsibility for the extra capacity required to serve the peak. Thus if demand at the peak were to rise while all other demands remained constant, only the customers at the peak would have to bear the extra cost.

Note also that the cost charged to any kilowatt of demand will depend on its timing: the higher the system demand at any time, the higher the cost per kilowatt at that time. While every customer must pay some share of demand costs, there is definite peak responsibility.

An interesting implication of the method is that if the whole system has a load factor of 100 per cent, then demand costs will be allocated by kilowatt-houhour, taking no account of the load factors of individual customers. This is entirely appropriate,

---

[51]C.S. Reed, "Veal, Hide, and By-Products", *EW* 90 (1927), p. 402. See also p. 798, and p. 1104.

[52]One aspect of this has already been discussed; this has to do with defining customer classes.

[53]See P. Lauriol, "Tarification de L'Energie Electrique", *L'Eclairage Electrique* 22 (1902), p. 325; H.E. Eisenmenger *Central Station Rates in Theory and Practice* (Chicago, 1921); M. Schwabach, "Zur Tariffrage der Elektricitatswerke", *ETZ* 24 (1903), p. 495; and R. Arbeiter, "Tarifbildung beim erkaufe Elektrischer Energie", *EuM* 32 (1914), p. 487. Also developed independently by W. E. Eggleston in 1946 (memorandum in file).

[54]The method theoretically requires allocating costs for each and every instant when the system is in operation.

since each and every customer is exactly filling up the valleys other customers created; for "diversity is the result of a mutual relationship and is not the property of one class of service". (See the discussion of Method 5 above.)

One criticism of this method is that it would require a customer with a load factor of 100 per cent to bear demand costs greater than those required to serve him alone. Take the acccompanying example:

Customer	Demands Hour I	Demands Hour II
A	6	6
B	6	0
Total	12	6

In this example, we should first allocate nine kilowatts to Hour I and three kilowatts to Hour II. Customer A would be charged for half the nine kilowatts of Hour I and all the three kilowatts of Hour II, or 7.5 kilowatts in all. Yet no more than six kilowatts would be needed to serve A alone.

This criticism is mistaken, for one main reason. It assumes that what a utility wants is customers having each a load factor of 100 per cent; in fact, though, it is only for the overall system that a load factor of 100 per cent is devoutly to be wished. Furthermore, an added off-peak customer is less costly and more valuable than an added customer with a load factor of 100 per cent, since the latter adds to the peak demand of the system. Yet again, to propose charging a customer with a load customer for no more capacity than what would be required to serve him alone is, at least in the context of the present example, to propose giving off-peak use a free ride. But since off-peak use is, after all, use, it must bear some share of capacity costs. Finally, this is another version of changing a customer for who he is rather than what he is. Suppose that, in the previous example, the six kilowatts of demand in Hour II were C's, rather than A's. Ought that to make any difference to the amount of cost allocated to them?

The main drawback of this method is the great amount of data needed to apply it properly. One would need to know each customer's demand at every instant of the year.[55] Such data are not generally available, and would be very hard and costly to gather. One might manage to reduce the data required to a small fraction of what theory would dictate, substituting various approximations or simplifying assumptions. Even so, the method would probably require substantially more data than most other allocation methods.

10. Method of Seasonal Distributed Responsibility[56]

Attributed to G.E. Quinan (1921), this method is a variant of Method 9. According to the Commonwealth Edison brief, "Load curves for a characteristic day of each of the four seasons are formed into a composite load curve and used as the basis for ... distributing the costs to service hours". This is clearly an attempt to simplify Method 9, rather than to improve it. Some questions remain about what a "characteristic day" is, why the peak days are ignored, and why a "composite load curve" is constructed, as if the only significant time differences in load varied with time of day rather than season.

11. Method of Monthly Distributed Responsibility[57]

Another variant of Method 9, attributed to M. Schwabach (1903), this method differs from 10 in that an average daily load curve is constructed for each month instead of each season.

12. Theory of Marginal Distributed Responsibility[58]

Still another variant of Method 9, attributed to J.A. Nordin (1946), this takes into account the costs of the equipment required to serve system loads of different sizes. If, for example, a hydro plant were used solely for peaking-purposes, only customers at the time of system peak would be charged the higher unit investment costs of that plant. This contrasts with other methods, which assign average historic cost to all kilowatts of capacity. The method seems to be appropriate only insofar as the utility buys certain types of equipment expressly in order to use them only for peaking.[59]

But merely because a utility will generally use its most recent and efficient equipment to serve the base load, and reserve older and less efficient equipment for use only when demand is relatively high, it does not follow that the on-peak customers should be the only ones to bear the cost of this older equipment. It is the newest rather than the oldest equipment whose presence in the system is owing to the peak demand, and a method which would distribute costs in just the opposite manner is illogical.

13. Multiple Plant Method[60]

This variant of Method 9 is attributed to G.H. Moore (1923). The Commonwealth Edison brief characterizes it as follows:

A variation of the distributed responsibility method using plant multiples instead of average kilowatt capacity costs.

This is not altogether clear, but it appears to be a variant of Method 12. It may, however, be interpreted as a means of taking into account indivisibilities of capacity. Suppose, for example, that a system has five generators, each with a capacity to serve 20,000 kilowatts of demand. From the point of view of capacity costs, it would not matter whether the system demand were 90,000 kilowatts or 95,000 kilowatts, since either way exactly the same capacity would be running. Thus the costs of the fifth generator would be equally divided among all the time periods when it was running (that is, when system demand was over 80,000 kilowatts), While this method has a certain attractiveness, it would not really carry conviction unless generators could only be bought in one size. Since that is not so, a demand of 90,000 kilowatts is in truth different, in terms of capacity requirements, from one of 95,000 kilowatts, indivisibilities notwithstanding.

14. Method of Distributed Responsibility as Modified by Schneider[61]

This is another variant of 9, attributed to R. Schneider (1932). The Commonwealth Edison brief describes it as follows:

[55] In practice an 'instant' might be a period of 15 minutes, 30 minutes, or an hour.

[56] G.E. Quinan, "Apportioning Power Costs Among Various Classes of Consumers", *EW* 77 (1921), p. 1495. See also vol. 78 (1922), p. 321.

[57] M. Schwaback, "Zur Tariffrage der Elektricitatswerke", *ETZ* 24 (1903), p. 495.

[58] J.A. Nordin, "Allocating Demand Costs", *Journal of Industrial and Public Utility Economics* (May 1946), pp. 163-170.

[59] The same treatment would apply to the costs of electricity purchased at the time of system peaks.

[60] G. Moore, "The Multiple Plant Method for the Equitable Apportionment of Fixed Charges", *AIEE Journal* 42 (1933), p. 408.

[61] Referred to by Schiller, p. 13; see R. Schneider, "Ein Praktisches Verfahren zur Verteilung der festen Kosten", *ETZ* 53 (1932), p. 174. See also pp. 5 and 33. *Note:* for other modifications of the theory of Distributed Responsibility see A. Schwaiger, "Die Verteilung der festen Betriebskosten", *Elektrizitatswirtschaft* (1933), p. 197.

Modification uses rather arbitrary generating "capacity units" instead of kilowatts of capacity. The resulting proportions differ somewhat from the ratios obtained with the original method.

The exposition and principle seem illogical at best.

15. Complete-Peak Method[62]

This method is attributed to J. Oram and H. Robinson (1928). It differs from the last method in that it considers only periods of above-average demand[63]
for the system and the customer class. The steps in the allocation procedure are as follows:

1. The cost of capacity required to serve the system's average demand is allocated by kilowatt-hour.
2. The costs of the rest of the capacity (the idle capacity) are allocated among only those time periods when demand exceeds the average. This allocation is similar to a distributed-responsibility allocation; the idle capacity is allocated to each time period roughly in proportion to the amount by which demand at that time exceeds the average demand of the system.
3. The idle capacity allocated to each time period is then allocated among individual customers in proportion to the amount by which each one's demand in that period exceeds his average demand.

This method is really a variant of the Method of Distributed Responsibility. It differs only in the way it focuses on above-average demands. The purpose and effect of this is to assure that no customer with a load factor of 100 per cent is charged with a greater proportion of capacity than would be required to serve his demand alone. Using this method, no customer will be charged a lower capacity cost per kilowatt-hour than the customer with the load factor of 100 per cent. The desirability of this has already been discussed in the criticism of the Method of Distributed Responsibility.[64]
The Complete-Peak Method appears to be just a modification of the D.R. method made to avoid or meet this criticism. The results of the two methods do not appear to be very different; the Complete-Peak Method usually allocates somewhat less to customers with a high load factor than the Method of Distributed Responsibility, and more to those with low ones. This means that customers with high factors will not be charged any more than ones with low ones whose demands are entirely off peak.

16. Modified Complete-Peak Method[65]

This is a variant of 15, differing in step (3). Costs are allocated among customers in the periods of above-average demand in proportion to their demands during those periods, rather than (as in 15) in proportion to their excess demands (that is, the customer's demand in excess of his average demand). Thus the costs allocated to customers with a load factor of 100 per cent do reflect their contribution to the system peak, (as they do not in No 15) so that such customers tend to have higher costs than under Method 15. With this modification, the Complete-Peak Method approximates very closely to the Method of Distributed Responsibility. Criticism of the latter method is blunted and the rationale of the method seems to be lost. For it is now difficult to justify treating all below-average periods of demand in the same way, regardless of their relative levels of demand.

17. Phantom-Customer Method[66]

This method is attributed to H.W. Hills (1927). Suppose there were a "phantom customer", whose demands, added to those of present ones, would just suffice to give the system a load factor of 100 per cent. The capacity costs would then be allocated among customers in proportion to the kilowatt-hours consumed.[67] Since the phantom customer cannot bear his share of the cost, that must allocated among actual customers.

Note that a share of the total capacity is already allocated before the costs of the phantom customer, which are actually the costs of the idle capacity, are allocated. If (for instance) the system load factor were 60 per cent, then 60 per cent of the capacity costs would be allocated among existing customers by kilowatt-hours. The remaining capacity costs would then be allocated among customers in proportion to the difference between their demands at the time of the peak and their respective average demands.

When one gets past the abracadabra about the "phantom customer", this method rather resembles the Complete-Peak Method. It differs in one really important way, though; it allocates costs of idle capacity in proportion to excess demands at the time of system peak, rather than at the times covered by the complete peak. Thus it gives much greater weight to the single system peak, and suffers accordingly from the weaknesses of the Method Peak Responsibility, including its unstable allocations.

It differs from the latter method in allocating only the costs of idle capacity to the peak-time customers, rather than the costs of all capacity. Thus off-peak customers bear a significant share of capacity costs. The minimum charge per kilowatt-hour is that charged to customers with a load factor of 100 per cent, a feature shared with the Complete-Peak Method.

Note also that one could modify the Phantom-Customer Method in the same way as the Complete-Peak Method, so that costs would be allocated to customers in proportion to their actual demands at the time of the peak rather than in proportion to their excess demands (over their own average demands) at the time of the peak.[68]

---

[62] J. Oram and H.H. Robinson, "The Complete Peak Method", *EW* 92 (1928), p. 359. See also pp. 573 and 1105.
[63] The "complete peak" refers to these times when demand is above average.
[64] The observation should be repeated here that if the whole system ran at a load factor of 100 per cent, the Complete Peak Method would (probably wrongly) allocate relatively more per kWh consumer to customers with low load factors and less to those with high ones.
[65] The apparent assumption is that the original theory was based on the mean demand for the peak day. See Schiller, pp. 18, 19 and 20.
[66] H.W. Hills, "Demand Costs and Their Allocation" *NELA Bulletin* 14 (1927), p. 346. See also H.W. Hills, "Why a Demand Charge?", *P.U. Fortnightly* 46 (1950), pp. 349-356; *EW* 89 (1927), pp. 198, 249, and 964; *EW* 90 (1928), pp. 165, 256, and 164; American Economics Review (August 6, 1927) p. 754; *ETZ* 49 (1928), p. 303; and W.J. Greene, C.F. Schoonmaker, and C.B. Gorton, "Allocation of Electric Service Costs", *EW* 80 (1922) p. 928 and pp. 878 and 1431. The last sets out a "Consumption and Excess Peak-Responsibility Method" which appears to be virtually identical with the Phantom-Customer Method, according to Schiller.
[67] Note that in a system with a load factor of 100 per cent this method (like No 9 and unlike No 15) would allocate in proportion to kilowatt-hours.
[68] In a system with a load factor of 50 per cent, this modification would give exactly the same allocation result as the "Atlantic Seaboard" formula the U.S. Federal Power Commission uses for gas pipelines. But interruptible service presents a different problem in principle. See "A Method of Calculating the Cost of Furnishing Electric Current and a way of Selling It", *EW* 27 (1896), p. 222; also W.J. Greene "Determining Demand Charge", *EW* 86, 1925, p. 947, and "Allocating Capacity Costs", *EW* 87 (1926), pp. 224 and 225; also "Excess Peak Responsibility vs Demand in Cost Studies", *EW* 89 (1927) p. 100; L.R. Nash, *Public Utility Rate Structure*, (New York, 1933); and the British Electrical and Allied Industries Research Association, *Technical Report Reference K/T106*, p. 15.

This method may be subjected to the following criticisms:

1. The treatment of customers with a load factor of 100 per cent is wrong (see above).
2. Far too much weight is given to the system peak.
3. There is no coherent rationale.

This method has one great practical advantage: it only requires data on customer demand for the time of system peak.

18. Method of Excess Demand[69]

This method, originally proposed in 1896, is attributed to W.J. Greene (1925). The cost of idle capacity, calculated as in Methods 15 to 17, is allocated among customers in proportion to each one's excess of maximum demand over average demand. This amounts, in essence, to allocating in inverse proportion to customer load factors. This method inherits all the shortcomings of the Method 5; but since it only applies to the cost of idle capacity, the burden is less. It also gives favourable treatment for customers with a load factor of 100 per cent who bear no portion of the charge for idle capacity.

The above describes a modification Greene made later in his original method. The latter is sometimes called the Consumption and Demand Method, and is usually presented algebraically with the following two equations:

1. $Kx + Dy = C$, and
2. $C/P = 24x + y$.

Of course, the algebra proves nothing. The first equation simply means that capacity costs charged to kilowatt-hours (or Kx, where x is the unit charge) plus the charge for capacity costs to customer maximum demands (or Dy, where D is the sum of the customer maximum damands and y is the demand charge) equals total capacity costs. Thus the assumption that customers ought to be charged in accordance with their respective maximum demands is arbitrarily introduced into the equations. This method appears to give the same result as the 'modification'.

19. Modified Excess Demand[70]

This method, attributed to a report of the British Electrical and Allied Industries Research Association (ERA) in the early 1940s, would allocate costs of idle capacity among only the demands in "potential peak periods": that is, when some normally possible increase in demand could create a system peak.[71] Inasmuch as this method emphasizes system peak rather than customer peak, it is a considerable improvement over Green's Method of Excess Demand. Depending on how the "potential peak periods" are defined, this method may come fairly close to the Complete-Peak Method.[72] A serious shortcoming of this method is that it involves a possibly significant element of subjective judgement in the choice of "potential peak periods". If the choice is made consistently, a shift in the time of the system peak will not produce any significant change in the cost allocations.

20. ERA Revision of Excess Demand Method[73]

This revision was advanced in an ERA report in 1945. All capacity costs, rather than just costs of idle capacity, are allocated according to demands in potential peak periods. Thus off-peak customers bear no capacity costs. While this method is historically a modificaiton of Methods 18 and 19, it is functionally a modification of the Peak-Responsibility Method. The rationale ERA offers is that this method "(allocates the cost to all customers whose decisions to consume more or less are liable to affect the undertaking's expenses, and only to such customers". But if demands are inelastic, then no economic purpose is served by this or any variant of the Method of Peak Responsibility;[74] and if demands are elastic, then economic purposes are better served by calculating marginal costs directly than by any allocation of sunk costs.

21. Refinement of the ERA Method[75]

The ERA's refinement, for which "no formula can be suggested", would be to "zone" the potential peak periods "so as to correspond with the different degrees of peak liability". This suggested refinement of No 20 extends the area of subjective judgement.

22. Kilowatt-Hour or Consumption Method

This is the simplest method; it would allocate in proportion to ki-

---

[69] M. Schwabach, "Zur Tariffrage der Elektricitatswerke", *ETZ* 24 (1903), p. 495.
[70] Report K/T106, p. 21.
[71] Recognizing that the excess demand theory may tend to charge the peak customer with less than his share of idle capacity, and may apparently overcharge the off-peak customer, P. Schiller attempted to correct this deficiency in part by proposing to base the maximum demand portion of the allotment upon demands "occuring only with in the daily period of human activity and the dark and cold season".
[72] It comes to exactly the same thing if the "complete peak", all periods when system demand is above average, is taken as the "potential peak period".
[73] Report K/T109, p. 11.
[74] Any theory which is more concerned with future than with present and past demand must be looking to economize future costs (past costs cannot be economized).
[75] Report K/T109, p. 15

lowatt-hours. It is too obviously unsatisfactory to merit any comment.

23. Sharing of Consumption and Maximum Demand[76]

This method is perhaps better described as the 'Atlantic Seaboard Formula', and has been used by the FPC in allocating costs of gas pipelines. The method involves allocating 50 per cent of capacity costs in proportion to total sales volume and 50 per cent in proportion to demands during a peak period. As has been noted already, the method is quite similar to one possible variant of the Phantom-Customer Method. It is also analogous to the Modified Excess-Demand and to the Modified Complete-Peak Method. The figure of 50 per cent was decided on by the FPC quite arbitrarily.

24. Straight Hourly Apportionment[77]

This method is attributed to G. Klingenberg (1924). The principle appears to be that since the equipment depreciates each hour, whether it is used or not, the customers in each hour ought to pay the depreciation in that hour.[78]
The perverse and illogical result of this method would be that unit capacity costs would be highest when demand was lowest. This would run contrary to any notion of economics, responsibility, or use of capacity.

25.Peak-Hour Method[79]

This method, attributed to A. Simpson (1928), is described in the Commonwealth Edison brief as follows:

> *Capacity costs are allocated to classes using power whenever the system load exceeds the "minimum daily load".*

It appears to be a variant of either the Complete-Peak Method or the Method of Distributed Responsibility, depending in part on what is meant by the "minimum daily load". More detail is needed to comment usefully on this method; but the method does not seem to add any new prinicple.

26. Price's Statistical Method[80]

Attributed to B. Price (1936), this is described as "Another rather complicated mathematical variation of the distributed responsibility method".

27. Value-of-Service Methods

These are not methods of allocating costs, but of setting rates.

28. Another Modification of the Method of Distributed Responsibility

Members of the Commonwealth Edison staff are supposed to have suggested this variant. Whenever the Method of Distributed Responsibility allocated a customer capacity beyond what was needed to supply his own peak demand, this excess would be redistributed among all other customers.

It must be admitted that this touches on the method's weakest point: namely, that the maximum demand of a class of customers depends in an artifical way on the definition of the class. Hence allocating capacity costs to a class beyond its maximum demand does not necessarily work an 'injustice'. For if the class were split in half, although the same total of costs would be allocated to the two new classes, the sum of the maximum demands of the two classes would be higher; hence what was an 'overcharge' when they were one class may not appear so when they are treated as two.

If the rationale of this proposed modification were accepted, then the most sensible approach to applying it would be to set as the maximum charge for each class the class maximum demand multiplied by the class diversity factor.[81] This would set as a maximum the sum of the costs needed to serve each customer separately.

It should also be pointed out that using the Method of Non-Coincident Peaks to set a maximum allocation for each customer class would probably tend to shift costs from customers with a high load factor, who do contribute to system peaks, to off-peak customers. It ignores the time at which class demands occur, and hence their use of peaking-capacity and their responsibility for it.

29. Modified Class Maximum Demands[82]

This method, attributed to R.E. Walden (1942), is described as follows:

> *Allocate the minimum used capacity charge to the 100 percent load factor customer; allocate some arbitrary low-cost to genuine off-peak customer; allocate the remainder using the class maximum demand method.*

All three steps are objectionable, at least in part. The favoured treatment of the customer with a load factor of 100 per cent has been discussed above. The use of our "arbitrary" allocation to off-peak customers has its obvious objections. The use of class maximum demands has already been rejected.

Summary

It is clear that many combinations of customer costs can be developed when the methods of dividing fixed costs between demand and energy are combined with those for allocating demand costs to customers. That is but one of the problems with the alternative approaches. While each possible combination of variants appears to be precise, there is no precise way to choose the correct combination. To restate the fundamental criticism of all the combinations: There is no relevant or meaningful way to allocate sunk costs to customers in order to achieve an efficient allocation of resources devoted to producing electricity.

---

[76] Interstate Natural Gas Company, Inc., 3 FPC 416, 48 PUR (NS) 267, (Federal Power Commission, 27 April 1943).

[77] As Lewis stated (pp 46 and 47), "Another solution makes each hour's customer pay for the amortization of the equipment during that hour, irrespective of capacity used ... (this solution) can be supported on the ground that it is equitable to make each hour's customer pay for amortization of the equipment during that hour irrespective of how much they use it." Schiller (p. 21) states that Klingenberg visualized spreading the whole standing cost equally over the entire length of the year concerned; see *Bau grosser Elektrizitatswerke* (Berlin, 1924).

[78] The same reasoning applies to return as to depreciation.

[79] A. Simpson, "Peak-Hour Cost Allocations", 92 (1929), p. 201.

[80] B. Price, "Evaluating Diversity Factor", *Electrical Review* 119 (I936), p. 400

[81] The "diversity factor" is generally defined as the ratio of the sum of the individual customer maximum demands to the maximum demand of the group as a whole. It varies directly with load factor, and customer classes with load factors between 30 and 70 per cent will have diversity factors of anywhere from 1.1 to 1.4 (See Bary, p. 54).

[82] R.E. Walden, "Cost Analysis for Electric Utilities", *Accounting Review* (July 1942), pp. 257-264

APPENDIX III: Background Paper: Conservation Through Inverted Rates: A Survey of Conservation Proposals[83]

A. THE CONSERVATION PROBLEM: THE CASE FOR AN EMERGING CONSENSUS

In support of the work in *World Dynamics and Limits to Growth*, I.M. Stelzer has said

> *It must be remembered that the dangers of misestimating the effects of population and economic growth on energy use are not asymmetric. If the rate of energy usage is underestimated, and if as a consequence no steps are taken to curtail this growth*, the world may find itself vitally short of fuel reserves, or of clean air and water.[84]

A report from the Ford Foundation's *Energy Policy Project*, comes to similar conclusions about energy, stating that there is an urgent need to conserve in order to achieve a "sustainable" economy in the United States. A "sustainable" economy is defined as consisting of a "social and economic order capable of living indefinitely in harmony with its environment".

This report is discussed in more detail below. Before proceeding, we also need a definition for the word 'conservation'. In this paper, the term means the redistribution of resource use to the future. Conservation, then, is desirable if, and only if, the discounted future benefits from postponing current consumption are greater than the present benefits from consuming today. Discounted future benefits are the opportunity, or user, costs of present consumption.[85]

1. Canadian

In 1974 Canadians consumed the equivalent of 50 barrels of oil per person, a rate that was growing faster than our Gross National Product. In 1971, the three most energy-intensive countries, on a per capita basis, were the United States, Canada, and Sweden. Americans used about one third more energy than Canadians. The average Canadian used about half as much again as the average Swede.[86]

As might be expected, Canadian energy consumption includes a high consumption of electricity; in 1973 Canada consumed more electricity per capita than any other leading industrialized country. (See the accompanying table.)

This high level and growth of energy consumption has led the Dominion Government to issue a strategy report that sets as its conservation goal reducing the growth of energy consumption from 5.5 per cent to less than 3.5 per cent a year. The report argues that low prices have induced high consumption growth, and that coupled with the diminishing resources available at low prices this will lead to serious shortage in the future. If prices

[84] I.M. Stelzer and L.J. Perl, "Energy Use and Population Growth" in *Proceedings of the Ninth World Energy Conference*, p. 5.

[83] This appendix, while not representative of the study team's view, is illustrative of a conservationist's approach.

[85] See A. Scott, *Natural Resources - a study of the Economics of Conservation*

[86] Energy, Mines and Resources Canada, *An Energy Strategy for Canada*, p. 130

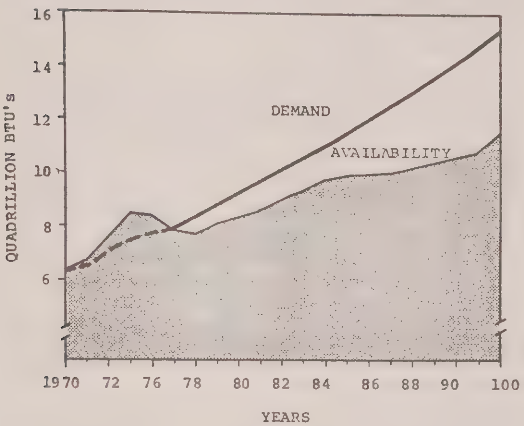
Comparative Data of Electric Utility Industries in Leading Countries of the World 1973*

	U.S.A.	U.S.S.R.	Japan	F.R. Germany	U.K.	Canada	France	Italy
Installed capacity (MW)	438,493	164,375	84,409	45,659	72,835	48,541	37,186	31,901
Total annual production per capita kWh	9,254	3,662	4,339	4,825	5,044	11,851	3,339	2,651
Transmission and distribution losses (%)	7.2	8.6	6.3	6.1	8.1	9.5	7.1	8.6

* Overseas Electrical Industry Survey, Inc., Electric Power Industry in Japan, 1975.

were kept at 1975 levels (except for gas), then shortages would be immediate and would increase in severity, as the accompanying graph shows.

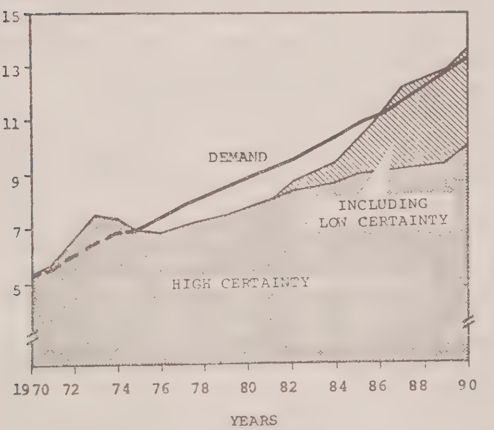
Domestic demand and availability: total energy (1970-1990; low-price scenario)*



* Energy Mines and Resources Canada, An Energy Strategy for Canada, p. 75.

But even if prices are allowed to climb to current international levels by the late 1970s, shortages will not be avoided; the second graph shows this scenario.

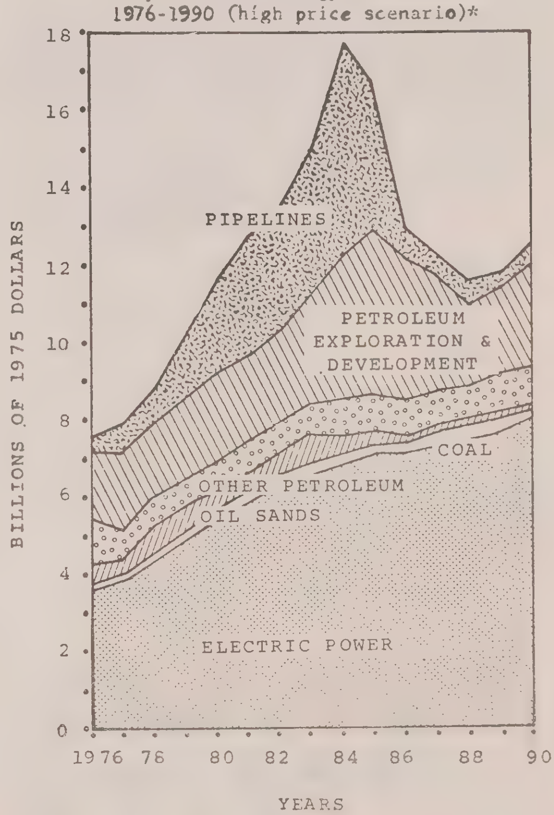
Domestic demand and availability: total energy (1970-1990; high-price scenario)*



* Ibid. p. 82.

The shortfall would occur mainly in natural gas, since the report makes a crucial assumption: electricity supply would be constrained only by demand, not by capital availability or any other factor. Insofar, then, as capital availability for electrical utilities may open a future gap between supply and demand at a low price, the Energy, Mines, and Resources (EMR) scenarios are overly optimistic. In fact, both scenarios assume electrical utilities will over-build, because generation planning does not take account of elasticity of demand, that is, customer-responsiveness to higher prices. Even EMR prescribes a general restraint in electricity growth, "a strong and a vigorous program directed at the *conservation of all forms of energy* is essential"[87] (emphasis theirs). From 1950 to 1975, energy-related investments demanded only 3.5 per cent of GNP; whereas from 1976 to 1980 5.0 per cent, and an average of 6.5 per cent from 1981 to 1985. (See the next graph.)

Components of energy investment, 1976-1990 (high price scenario)*



* Ibid. p. 82.

The high demand on capital markets that this charge implies may be impossible to meet. Capital requirements of the electric utility sector are projected to account for a little over 50 per

[87] *Energy Strategy*, p. 28.

cent, or $91.2 billion, of total energy investment in the high-price scenario, and over 76 per cent of the total in the low-price scenario.[88]

The years 1981 to 1985 are especially bad. Although, one may rely increasingly more on foreign borrowing, already high debt-equity ratios and our reluctance to allow high foreign equity investment in these projects may require some smoothing of the 1981 to 1985 investment peak.

The high-price scenario assumes an annual growth rate in electrical capacity of 5.9 per cent[89]
which would have to be reduced between 1981 and 1985. In order make that reduction, steps would have to be taken to introduce rates for 1978 or 1979 that would give the desired effect.

Such a price signal could be given by inverted rates. This may be viewed as one of the strongest arguments for the use of inverted rate structures for conservation.

There is a further national argument for conserving energy besides the problems of capital availability: the Canadian balance of payments situation. Our growing deficit in service transactions as well as a 1975 merchandise-trade deficit of $795 million in 1975 resulted in the following decline:

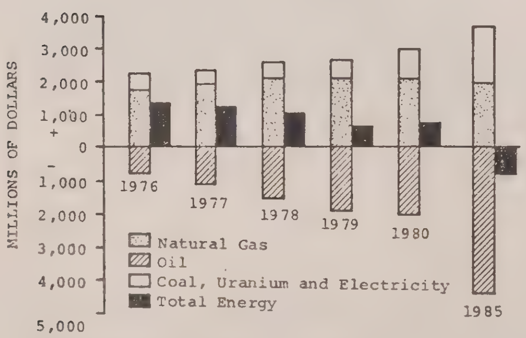
Current Account*
Balance of Payments
(in millions of dollars)

1970	953
1971	32
1972	-945
1973	-319
1974	-2187
1975	-5485

* Ibid, p. 113

One half of the 1975 merchandise deficit is attributed to the growing oil deficit[90]
forecasted in the accompanying figure.

Balance-of-trade in energy commodities*



* Energy Mines and Resources Canada, p. 113.

While in 1974 the oil surplus was $1,668 million[91], the oil deficit would climb to $4.5 billion a year by 1985. Foreign borrowing cannot bridge the gap for ever, as underdeveloped countries have recently found out. For Canada, in 1975, the balance of long-term capital inflow was $3,656 million, as compared to interest and dividend payments to foreigners of $2,000 million.[92]

2. Background Information

There is a growing consensus that the benefits of consuming electricity in the future exceed the benefits of consuming now This consensus might lead one to an objective of conservation.

If one were able to quantify the benefits of transfer of energy use to future generations, as well as all the externalities that are not now considered, then a price structure based on the efficiency objective would theoretically be the same as one based on the conservation objective. In marginal costing, however, all valuations are explicit, and such implicit valuations of future benefits are not used, except for those arrived at through national consensus.

What rates of energy growth have been proposed for conservation purposes? The most well-known international debate has been over zero energy growth.

What is the meaning of this concept? As generally applied, it refers only to non-renewable energy resources, and is calculated on a per capita basis. The best description of it is found in the Ford Foundation study of energy policy.

Its proponents advocate ZEG on the grounds of long-run stability and recommend attaining the goal gradually. The Ford Foundation study finds that ZEG is feasible in the United States by 1990, if a start is made in 1975. The ZEG future emphasizes growth in employment-producing sectors such as services, cultural activities, urban amenities, and other endeavours that require little energy per dollar of output. This future de-emphasizes heavy industrial activity or primary processing of metals. Some other writers have recently suggested that countries rich in energy should set up energy havens to attract these industries. ZEG is a compatible solution to the world-wide problem of limits to growth as posed by the Club of Rome. Canadian energy strategy postpones addressing the global problem.

By the year 2000, the ZEG future foreseen in the Ford study would still have production and a stock of materials much greater than that of 1974, but with a premium placed on quality and durability of consumer goods, so that production in each year could be lower than otherwise. Recycling materials would also be encouraged to minimize the energy needed to produce new materials. In stating the case for ZEG, the project team warns "An energy saving (conservation program) that simply squeezes the waste out of the ongoing pattern of growth can only buy time".

Data Resources Inc. built an economic model for the project that simulated growth in the United States from 1975 to 2000 under different energy and supply conditions. ZEG by the year 2000 would reduce real GNP by less than four per cent from the historical growth level (HGL), despite the fact that energy consumption would be only a little more than half of the historical

[88] *Energy Strategy*, pp. 107-108
[89] *Energy Strategy*, p. 58
[90] Wood Gundy Forecast *Canada's Balance of Payments*, April 1976, p. 1
[91] Wood Gundy, p. 1.
[92] Wood Gundy, p. 1.

level. Moreover, most of this reduction would be concentrated in the energy-producing sector. The money generated by the service sector would be about one per cent more than the HGL. Other sectors would be between -1 per cent and -3 per cent from HGL, while the energy sector would be -60 per cent from HGL (but still significantly higher than the 1974 level). ZEG requires less capital than either HGL or the technical fix scenarios. The latter would consist of efficient consumption of energy enforced by government, with an estimated growth in use of 1.9 per cent.

In the ZEG scenario, society chooses to restructure the economy so that demand for services for example for the arts, education, commerce, and recreation would grow a little faster than the demand for a second or third car, for example. The implication is that society needs to have the choices presented through a quantitative and analytical report, such as that made by the Ford Foundation, in order to know enough to make the proper economic decisions.

Personal consumption according to the HGL would be 140 per cent of the 1975 amount, while under ZEG it would be 125 percent. Under ZEG there would also be a shift of one per cent from personal consumption to the government sector.

In comparison with the technical-fix scenario, ZEG gives a lower level of energy use in the year 2000 for the transport industry. Industrial energy use would also be lower, with half the savings concentrated in such industries as plastics, aluminium, and steel. Residential consumption of energy is about the same as in the technical fix, while the commercial sector would use *more*. Under ZEG, by the year 2000, all families would have a 100-per cent saturation of major appliances, including freezers. There would also be a switch from fossil fuels to electricity for cooking.

Even though electricity is expected to replace some primary fossil fuel under ZEG, the rate of growth is considerably below the historical one of between six and seven per cent a year. The Dominion Department of Energy, Mines, and Resources has begun to take steps to obtain similar data for Canada. Its report on energy strategy was based on an analytical framework forecasting energy use on the basis of historical relationships, and demographic and economic activity. It allows substantial scope for adjusting historical relationships based on anticipated reactions to changing energy prices and technology. For example, the share of total energy use comprised by primary electrical energy is forecast to rise from 26 per cent in 1975 to about 31 per cent by 1990, owing to continuing substitution for oil and other fuels.[93] Since the Ford study findings imply an electrical consumption growth substantially below historical growth levels, it is reasonable to expect that a similar decrease would be needed in Ontario. A cost-benefit analysis of conservation cannot be adequately measured in dollars and cents. The calculation will be implicit, rather than explicit. In fact, it would have to be a growing consensus of society that the benefits of present con-

[93] *Energy Strategy*, p. 52.

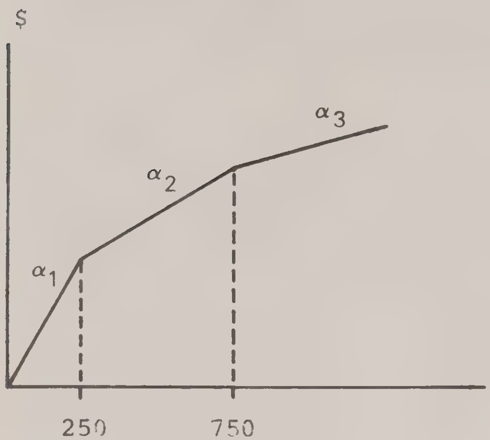
Total Energy Use in the United States Under ZEG
In Quadrillion BTU's

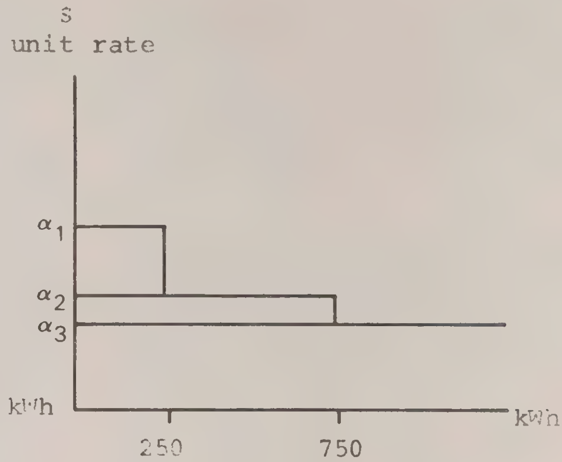
	1973	1985	2000
	75	88	100
Increase each period		17.3%	+13.6%
Simple annual increase		1.44%	.91%
Compounded rate of increase		1.34%	.86%

Central-Station Electricity: ZEG

	1973	1985	2000	1973-2000
	19.8	23	31	
Increase each period		16.2%	+34.8%	56.57%
Simple annual increase		1.35%	2.32%	2.1%
Compounded rate of increase		1.25%	2.01%	1.67%

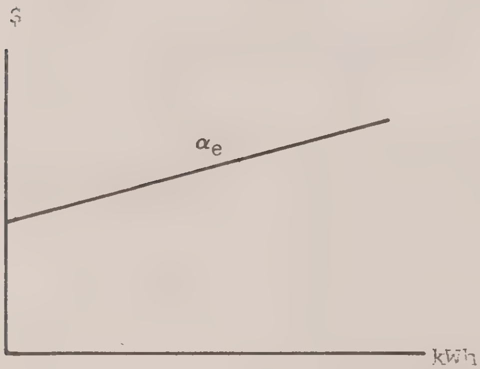
Average Cost Pricing - Illustration of total bill paid with a declining block kWh charge:

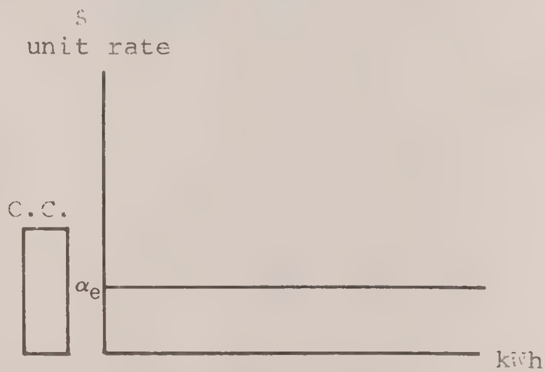




The declining block structure is characterized by the slopes of the total bill lines $\alpha_1 > \alpha_2 > \alpha_3 > \alpha_i$

Using marginal cost-based pricing with a customer charge and a flat kWh charge we get:





Comparing with average cost pricing $\alpha_e > \alpha_3$

sumption are less than the present value of the future stream of benefits.

The pros and cons of ZEG (or low electricity growth) for conservation and of the use of inverted rates to achieve this object are discussed under each of the pricing policy alternatives.

B. Policy Alternatives in Pricing for ZEG or Low Energy Growth

1. Inverted Rates, Traditional Rates and Marginal-Cost Rates

For purposes of discussion, bill information using average-cost, marginal-cost, and inverted-rate pricing is presented on the first two accompanying graphs.

The total-bill illustration for an inverted rate structure uses an increasing-block kilowatt-hour charge, as can be seen on the third graph.

Although the concept of a customer charge can be used with inverted rates, it would tend to flatten the total bill curve when the revenue requirement must not be exceeded and when the surplus is partly distributed back to the customer charge. The idea is to achieve a progressively steeper total bill curve to encourage conservation. This can be accomplished better without a customer charge.

Inverted rates are justified by the transfer of resources to the future and the uninternalized social costs. Robert Smith of the Canadian National Energy Board called for inverted rates on these very grounds at the 1973 Iowa Rates Conference. He stated that inverted rates are cost-based, in that they do not exceed the revenue requirement, although they do not claim to be cost related to each block; but "no utility has placed in evidence a cost of service study on a block-by-block basis". Citing the application of inverted rates to the water supply of Kingston, Jamaica, he notes "After introduction demand fell and from then increased at a *much slower rate*".

Effectiveness would be measured in terms of achieving a predetermined growth rate. The planned growth rate would be set after consulting with government on energy substitution, the availability of capital, the balance of payments, conserving energy for future generations, and the overall desired rate of growth of energy. In sum, it gives us the growth-rate for electricity that is consistent with a conservation objective. If the desired rate for the growth of industrial electricity for 1985 were 3.2 per cent, then a schedule of the plan might look like the accompanying table.

Three policy alternatives are outlined as ways of achieving a rate of growth for electricity compatible with a ZEG or low growth target. Two of these alternatives use variants of inverted rates; the third, for purposes of comparison, is the alternative of rationing electricity. Other forms of pricing are not considered as feasible, since a seven-percent rate of growth in the demand for electricity must be reduced to a sustained long-run annual growth of about two per cent under ZEG, or three to four per cent to meet the standards of *Canada's Energy Strategy*. The actual demand levels for average annual electricity growth cannot be established until (a) a target year is chosen for ZEG or a low rate of growth, and (b) an energy simulation model is built.

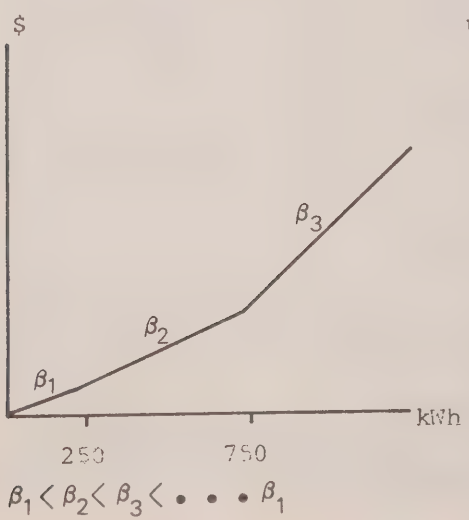
C. The Three Policy Alternatives for Electricity Pricing for ZEG or Low Growth

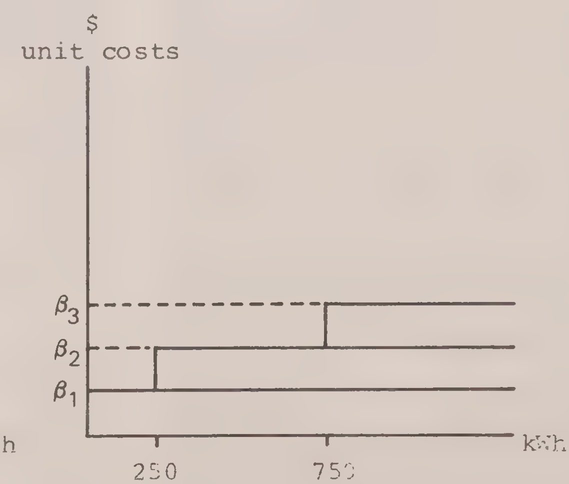
1. Apply inverted rates and exceed revenue requirement; turn the excess over to the government to enable it to lower taxes elsewhere.

This is equivalent to the gradually introduced tax on energy proposed by the Ford Foundation study. This approach would allow setting an earlier target date for ZEG.

This alternative should be used only if other energy forms are also priced by inverted rates. Exceeding the revenue requirement, the equivalent of tax on excessive consumption of energy, should apply on a broad basis to avoid having large numbers of consumers move into other energy forms, and hence not achieving substantial conservation of energy overall.

This might be a quick and relatively easy way to avert energy





	forecast	planned	actual	variance	plan for eliminating variance
1978	7	6.7			
1979	7	6.2			
1980	7	5.7			
1981	7	5.2			
1982	7	4.7			
1983	7	4.2			
1984	7	3.7			
1985	7	3.2			

shortages in the 1980's, decrease the oil trade-deficit, and at the same time release capital for investment in commerce and the service sector in general. In this alternative there would be no need to track costs, unless we included in our social costing the need for energy self-reliance, the capital availability constraint, and so on. Although the conservation objective would be attained sooner, the economy would have less time to restructure itself to allow growth in the service sector, generally decreasing the quantity of energy-intensive goods, and increasing the recycling of materials. The result might be a loss of job opportunities and family hardship until people directed their education and skills to the new growth sectors over a number of years.

2. Do not exceed the revenue requirement, but apply inverted rates so that initial block rates are lower and end block rates are higher.

Distortions are minimal if demand is highly inelastic in initial blocks compared to tail blocks, and if the tail block rate does not significantly exceed social marginal costs. The amount of decrease for the initial blocks and the height of the tail blocks depends on assumptions about the elasticity of the price for tail blocks and how early the target date is set for ZEG. A variant of this procedure uses the customer charge and increasing block rates.

One of the first decisions to make is whether to use the revenue requirement as a limiting factor. Japan and Mexico use it, because it has the attraction of leaving rates on a basis where the revenue requirement is not exceeded. The Ford Foundation study suggests energy prices would remain too low to achieve ZEG unless a fifteen-per-cent energy tax were introduced gradually. Although that study considers time-of-day pricing, it does not consider inverted rates. Taking a conservative approach, it would be more appropriate to introduce inverted rates that do not exceed the revenue requirement and monitor the results. If low-use customers increase their consumption because they are price-elastic, then an energy tax can be contemplated at a later date. Low-use customers are, however, assumed to be relatively price-inelastic.

Weight is given to this assumption by a study carried out by J.W. Howe.[94]

At the time of high surcharges in Jacksonville and Orlando, Florida, in 1973 and 1974, households in the 0-300 kilowatt-hour bracket managed to increase their consumption. Those in the higher brackets, 800 kilowatt-hours and more, especially those in the 1,800-kilowatt-hour class, their consumption. Price elasticity in the upper consumption brackets, and lack of elasticity in the lower brackets, make rate inversion for conservation an even more attractive plan. The empirical study covered 110,000 households, and data were adjusted for heating and cooling degree-days and short-run elasticities calculated for 18 levels of consumption.

Furthermore, the appraisal of inverted rates carried out by New York State re-inforced this finding: "For example, power consumed in blocks 501-800 kWh, 801-1,000 kWh and 1,001-1,-500 kWh rose by +100%, +125% and +160% for Niagara Mohawk. The increases for the block of 200 kWh and under were much lower".[95]

Some of these factors may have been responsible for the Michigan Public Service Commission's order to Detroit Edison to institute inverted residential rates along with time-of-day pricing for commercial and industrial customers. About five per cent more each month is to be paid for consumption in the 501-1,000 kilowatt-hour block than in the base 0 to 500 kilowatt-hour block, and an additional five per cent for energy used beyond 1,000 kWh per month.[96]

Industrial applications of inverted rates may partly face the need of controling fragmentation. An electrically intensive company may decide to break itself up on paper into many companies to enjoy the benefits of low initial-block rates for each company. There are legal, accounting, and other costs associated with such a step, and it may be that few companies would make such a move to save money on electricity alone. In becoming separate entities, some of the economies of scale in production might also be lost. In the case of a mere paper fragmentation, regulations may be needed to prevent avoiding the inverted rates. Inverted rates in industrial applications should also find favour with small businesses and enhance their competitiveness with industrial giants. Some critics have argued that this policy would increase industrial pollution, because smaller businesses cannot afford, nor are they always required, to control pollution. The criticism, however, is speculative, and fails to take concentration of pollutants into consideration.

3. Ration electricity

This is not really a pricing-mechanism, but does provide a way of approaching ZEG. Load-shedding, load-control and switching-devices would be extensively used, along with a schedule of priorities of use. Priorities would be set on the basis of necessity and fairness; for example, hospital and life-support systems first,

[94]J.W. Howe, "Lifeline Rates - Benefits for Whom?", *Public Utilities Fortnightly*, January 1976, p. 23

[95]Diana Sanders, The Inverted Rate Structure (New York State Department of Public Service, 1972), p. 41

[96]"Mich. PSC Orders Inverted Home Rates, Limits DE's Fuel Pass-Along to 90%", *Electrical Week*, April 12, 1976

followed by residential, essential industrial and commercial, and finally, non-essential industrial and commercial uses. The criteria for this schedule might include evaluating the disruption in the daily pattern of life if, for example, a certain large enterprise failed to operate and many people were thrown out of work.

D. USE OF INVERTED RATES IN OTHER COUNTRIES

The following is a description of the situation in Sweden, Japan, and Mexico where inverted rates have been applied:

1. Sweden

Sweden has a population less than half that of Canada. Its GNP per capita is slightly better than ours, yet it uses only about half as much energy per capita as we do. Moreover, after an extended national debate on energy and nuclear safety, the government declared in May 1975 their aim of achieving a zero rate of energy growth by 1990. This policy embodies an ongoing rate of energy growth of two per cent a year, tapering to zero by 1990. During this time, a substantial shift of energy use to electricity is foreseen. Therefore, the demand for electricity is to be allowed to grow at an annual rate of six per cent, in order to reduce the consumption of fossil fuel, since Sweden has no viable supply of its own. Despite the nuclear controversy, 13 nuclear reactors have been approved in Sweden, bringing nuclear generation to more than 50 per cent of electricity generation by 1985.

The six-per-cent rate is substantially higher than the rate of one to one-and-a-half per cent for central-station electric power simulated in the Ford Foundation study. The situation in Sweden is different, however, because generating-stations already provide district heating to 25 per cent of the population as a by-product of electrical generation, and this is forecast to increase to around 40 per cent.

2. Japan

Japan is poor in all kinds of energy, depending even on coal and uranium imports from Canada and the United States. Although geothermal potential is assessed at 20,000 megawatts, only 64 megawatts are developed, which could grow to 2,100 megawatts by 1985. Japan's rate of growth in demand for energy between 1962 and 1971 averaged 11.9 per cent, or more than double the world average of 5.4 per cent. By comparison, electrical energy demand increased by 9.7 per cent in the fiscal year 1973, with a commercial increase of 11.6 per cent[97] and an industrial one 10.3 per cent. The annual load factor in 1969 was 69.8 per cent, one of the highest in the world.[98]

The energy crisis of October 1973 hit Japan particularly hard, decreasing load growth for 1974 to 0.2 per cent. Japan's electrical industry depends on oil for about 70 per cent of generation. To decrease this dependency, the country has undertaken an ambitious nuclear program, which is now suffering from site-selection problems and lack of capital. Revenue requirements necessitated a 1974 rate increase of 57 per cent, 29 per cent residential, and 74 per cent for others.

In 1974 this situation prompted the Japanese electric utility group to propose to the Ministry of International Trade and Industry (MITI) that inverted rates should be used in the interests of future conservation.[99]

The first 125 kilowatt-hours a month supplied to residences would be billed at slightly below cost, 125 to 200 kilowatt-hours would be sold at a rate about equal to average cost, and the rest at higher than average cost. The inversion of the rates was further extended to commercial and industrial customers, who would face progressively higher increases than the residential market "to make the customer share an incremental cost in proportion to the additional demand over a certain limit . . . and applicable to both the basic charge and the energy charge of such higher demands".[100]

In 1975, the Impact Committee wrote to the Chubu Electric Power Company in Nagoya to ask for further details. Chubu is the third largest of the nine electric utilities in Japan.

Ever since 1951, Chubu's sales of kilowatt-hours had increased at an annual rate of 13 per cent. Capital-cost and energy-cost increases forced Chubu to join the other utilities to ask for rate inversion. Moreover, as the utility pointed out, rapid economic growth has resulted in an unequal distribution of wealth, and inverted rates were proposed with the additional object of promoting national welfare.

Commercial and industrial rates depend on the level of use. All contractual levels were frozen on a certain date. Established demands are charged at average cost; new demands, including all demands of new customers, at increasing costs. However the rate of increase of the rate level, although not of the total bill, tapers off slightly with each added block. (See graph.)

This might solve some of the problems of industries' fragmenting demand in an attempt to avoid inverted rates. It would help to attain a conservation objective, but might not be an efficient or feasible way of attaining zero energy growth an objective which Japan has not adopted.

After eleven months of implementation, the residential load increased by 3.9 per cent on an annual basis, while other loads decreased by 5.5 per cent, resulting in an overall decrease, from April 1974 to March 1975, of 3.9 per cent. In May of 1975, Chubu was understandably not yet sure how much of the change to attribute to inverted rates, and how much to Japan's recession and a popular, but perhaps temporary, conservation ethic not based on costs.

Chubu's rates are displayed in Annex 1. Although there is no mention of other energy's being priced by inverted rates, it is implied that conditions of supply and other controls, such as government allocations, may be sufficient to prevent potential market distortions through substitution of gas, oil, or coal for electricity.

At the time of writing, the most recent information for Japan ran to September 1975. Load growth for 1975 was up by 5.0 per cent over 1974, but still less than one third of the 1973 level. Kilowatt-hour output was up by only 2.3 per cent, compared with a decrease of 1.2 per cent in 1974. (See the accompanying table.)

Japan started to come out of the recession in the second quarter of 1975. Although residential energy sales increased substantially over 1974, the situation was caused by the unusually cool summer in 1974, and extremely hot weather in 1975. Large users continued to decrease their take, at least in part owing to the inverted rates.

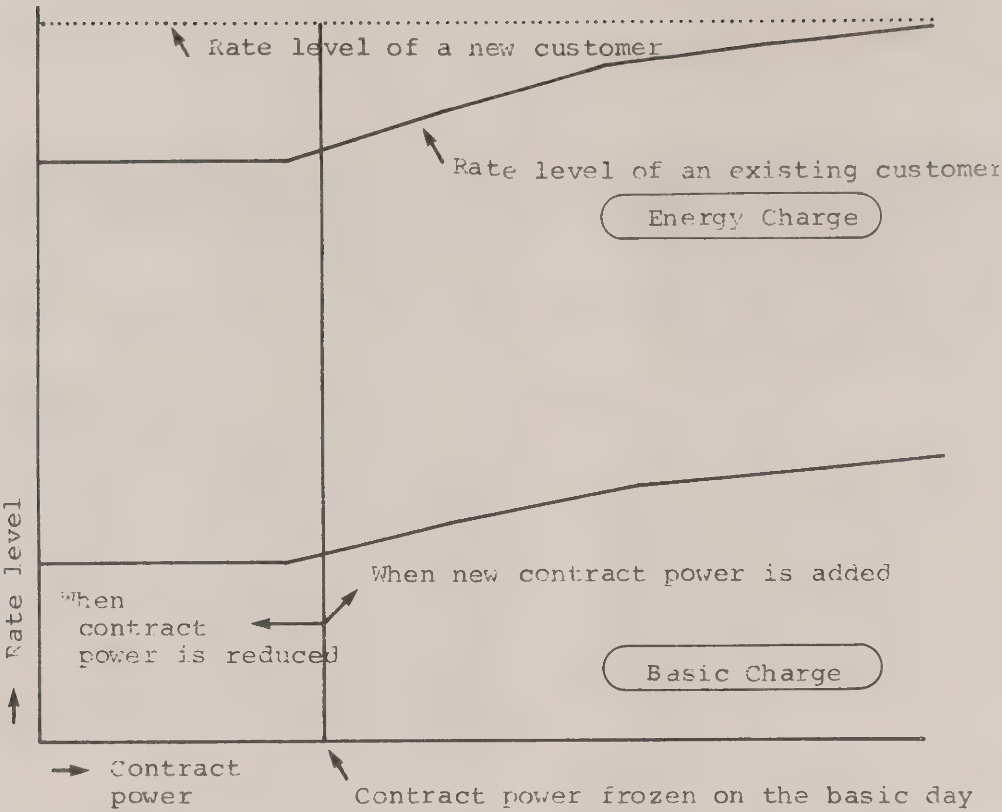
---

[97] Overseas Electrical Industry Survey Institute, Inc., Electric Power Industry in Japan, 1974, p. 46.

[98] *47th Semi-Annual Electric Power Survey, October 1975*, Japan Electric Power Survey Committee, Tokyo, Dec. 1975.

[99] "Japanese Utilities Request Inverted Rate Structure for New Rates", *Electrical Week*, April 1, 1974

[100] *Electric Power Industry in Japan, 1974*, p. 46.



Percent Wage Increase in Annual Energy Requirements
(at consumer's end)
for Japan*

	1969	1970	1971	1972	1973	1974	1975
Lighting	14.5	14.2	13.3	11.7	10.8	3.9	9.8
Commercial power	21.5	21.0	22.2	19.0	12.2	1.5	14.2
Small power	13.0	11.0	7.4	10.3	10.9	(2.7)	3.5
Large power (over 500 kW)	14.5	12.3	4.6	9.7	9.8	(2.5)	(5.3)
Total energy requirements (including sub-station service and other power)	14.9	13.2	8.2	11.2	10.8	(1.0)	1.2

3. Mexico

In contrast with Japan, Mexico recently discovered enough oil to satisfy domestic demand and to become a net exporter. However about 80 per cent of the electrical energy generated is hydraulic. Nevertheless, it has adopted inverted rates for electricity. The study group wrote to the Cia: de Luz y Fuerza del Centro for further details. As of 12 May, 1975, the utility still had in force a rate schedule issued 16 October, 1973, although some revision was anticipated in the near future. The respondent believed that inverted rates, which had been introduced for the whole of Mexico, were used in this schedule for the first time. Besides increased costs for new generation, there appears to be a conscious objective to redistribute wealth. Nevertheless, inverted rates apply only to residential, general (up to 40 kilowatts), and farm-irrigation loads. Government rates are flat, and industrial rates are of the declining-block-rate type. Mexico may be attracting industry by keeping industrial rates low, in order to improve employment. Certainly the inclusion of farm irrigation in the inverted rates seems to represent an attempt to conserve. One year's experience with two million customers had the results shown in the accompanying table.

As elsewhere, the situation was affected by world recession. Nevertheless, the growth in residential demand, usually representing a stabler growth path during economic slow downs than large industry, dropped from six per cent to one per cent.

E. CONCLUSION

A very low growth objective may be the only means of reducing energy demand to meet the conservation objective stemming from intermediate run supply conditions, capital scarcity, and Canada's need for self-reliance in energy.

F. BIBLIOGRAPHY

1. Baumol and Oates. "On Optimal Pricing of Exhaustible Resources", in *The Theory of Environmental Policy*, Englewood Cliffs, N.J., 1975.
2. Department of Energy, Mines, and Resources, Canada. *An Energy Strategy For Canada: Policies for Self-Reliance*, Ottawa, 1976.
3. Fisher, A.C., and J.V. Krutilla. "Valuing Long Run Ecological Consequences and Irreversibilities", *Journal of Environmental Economics and Management*, August 1974.
4. Ford Foundation Energy Policy Project, *A Time to Choose: America's Energy Future*, Cambridge, Mass., 1974.
5. Forrester, Jay W. *World Dynamics*, Cambridge, Mass., 1971.
6. Gratstrom. *Energy Problems in Sweden*, Swedish State Power Board, 1974.
7. Hase, F.K. "Energy and the Quality of Life", *Canadian National Energy Forum*, 1974.
8. Hayes, D. *Worldwatch Paper 4, Energy: The Case for Conservation*, Worldwatch Institute, 1976.
9. Howe, J.W. "Lifeline Rates - Benefits for Whom?", *Public Utilities Fortnightly*, January 1976.
10. Japan Electric Power Survey Committee, *47th Semi- Annual Electric Power Survey, October 1975*, October 1975, Tokyo, December 1975.
11. "Japanese Utilities Request Inverted Rate Structure for New Rates", *Electrical Week*, 1 April 1974.
12. Lyberg, B.; G. Hambraeus; and R. Gradin. "Need or Demand for Energy (in Sweden) - and Analysis of the Energy Consumption", *Proceedings of the Ninth World Energy Conference*, 1974.
13. Meadows, Donella H.; Dennis I. Meadows; Jorgen Randers; and William W. Behrens III. *The Limits to Growth*, New York, 1972.
14. Mesarovic, M., and E. Pestel. *Mankind at the Turning Point*, New York, 1974.
15. "Mich. PSC Orders Inverted Home Rates, Limits DE's Fuel Pass-Along to 90", *Electrical Week*, 12 April 1976.
16. Myhra, David. "Zero Population Growth: Its Effect on the Demand for Electricity", *Aware*, March 1975.
17. Overseas Electrical Industry Survey Institute Inc. *Electric Power Industry in Japan, 1974*, Washington, D.C., 1974.
18. Overseas Electrical Industry Survey Institute Inc. *Electric Power Industry in Japan, 1975*, Washington, D.C., 1975.

Sales in GWh

Type of Customer	1972	1973	%73/72	1974	%74/73
Government	1,347.3	1,495.7	11	1,697.4	13
Industrial and mines (HT)	5,364.0	6,133.9	14	6,249.5	2
Commercial and industrial, other (LT)	1,625.5	1,683.8	4	1,752.3	4
Residential	1,609.3	1,713.7	6	1,737.4	1
Total	9,946.1	11,027.1	11	11,436.6	4

19. "Plant Seeds Saved As Insurance Against Diseases", *The Toronto Star*, Wednesday 21 April 1976.

20. Randall, A.; B. Ives; and C. Eastman. "Bidding Games for Valuation of Aesthetic Environmental Improvements", *Journal of Environmental Economics and Management*, August 1974.

21. Reed, D.J. "The Indigent Burden from Inverted Utility Rates", *Public Utilities Fortnightly*, 19 July 1973.

22. Sander, Diana E. *The Inverted Rate Structure - An Appraisal*, New York State Department of Public Service, 1972.

23. Smith. Robert. "Rate Inversion - A Necessity for the Future?", *Proceedings of the Twelfth Annual Iowa State Conference on Public Utility Valuation and the Rate Making Process*, 1973.

24. Stelzer, Irwin M., and Lewis J. Perl; "Energy Use and Population Growth", *Proceedings of the Ninth World Energy Conference*, 1974.

25. "Sweden's Energy Debate", *Energy Policy*, September, 1975.

26. "Swedish Report", supplement to *Modern Power Engineering*, July 1975.

27. Teller. Edward. *Energy, A Plan for Action*, Commission on Critical Choices for America, 1975.

28. Wilson, J.W., and R.G. Uhler. "Inverted Electric Utilities Rate Structures: An Empirical Analysis", *Proceedings of the Thirteenth Annual Iowa State Conference on Public Utility Valuation and the Rate Making Process*, 1974.

29. Wood Gundy. *Forecast: Canada's Balance of Payments*, April 1976.

30. Zarb, Frank G. "We Can Still Reach Energy Self-Sufficiency", *Public Utilities Fortnightly*, September 1975.

31. "Zero Growth Rates for Energy or Fuel?", *Energy International*, August 1975.

G. ANNEX 1

The Chubu Electric Power Co., Inc.
Electric Rates(per Month)

Contract Category	Application	Unit	Prompt Payment Rate(Yen)
Flat Rate Lighting (Total Capacity: 400VA or less)	•Customer Charge	per contract	35.00
	•Lamp Charge	per lamp	
	Up to and including 20W		78.00
	" 40W		126.00
	" 60W		174.00
	" 100W		270.00
	Over 100W, per 100W		270.00
	•Small Appliance Charge	per appliance	
	Up to and including 50VA		126.00
	" 100VA		196.00
	Over 100VA, per 100VA		196.00
	Radio Set of 20VA or less		56.00
	" 30VA "		78.00
	Iron Set of 300W or less		175.00
Meter Rate Lighting A (Contract Current: 5A)	•Minimum Charge (including first 8kWh)	per contract	190.00
	•Energy Charge(excess of 8kWh)	per kWh	12.00
Meter Rate Lighting B (Contract current: 10A ~ 60A)	•Basic Charge	per 10A of contract current	200.00
	•Energy Charge	per kWh	
	First 120 kWh		12.00
	Next 80kWh		15.40
	All Excess		16.82
	•Minimum Monthly Charge	per contract	190.00
Meter Rate Lighting C (Contract Capacity: 6kVA ~ 50kW)	•Basic Charge	per 1kVA of contract capacity	200.00
	•Energy Charge	per kWh	
	First 120kWh		12.00
	Next 80kWh		15.40
	All Excess		16.82

Temporary Lighting	Both of Basic and Energy Charges shall be the amount equivalent to the corresponding charge under Flat Rate Lighting, Meter Rate Lighting A, B or C as increased by 10%,		
Farm Lighting	The same as Temporary Lighting. However, for the period other than the contracted usage period, no basic charge is charged.		
Public Street Lighting A (Total Capacity: 1kVA or less, Flat rate service)	•Customer Charge •Lamp Charge Up to & including 20W " 40W " 60W " 100W Over 100W, per 100W •Small Appliance Charge Up to & including 50VA " 100VA Over 100VA, per 100VA	per contract per lamp per appliance	30.00 70.00 113.00 156.00 242.00 242.00 113.00 176.00 176.00
Public Street Lighting B (Contract Current: 10A ~ 60A)	•Basic Charge •Energy Charge •Minimum Monthly Charge	per 10A of contract current per kWh per contract	180.00 10.85 170.00
Public Street Lighting C (Contract Capacity: 6kVA ~ 50kVA)	•Basic Charge •Energy Charge	per 1kVA of contract capacity per kWh	180.00 10.85
Light and Power (Contract Power: 500kW or more)	•Basic Charge Ordinary Rate When supplied at 6,000V " 20,000V or 30,000V " 70,000V Special Rate When supplied at 6,000V 20,000V or 30,000V " 70,000V	 per kW " " per kW "	 840.00 800.00 765.00 1,010.00 960.00 920.00

	•Energy Charge When supplied at 6,000V 20,000V or 30,000V " 70,000V	 per kWh " 	 10.75 10.30 10.00
Low Tension Power (Contract Power: less than 50kW)	•Basic Charge Ordinary Rate Special Rate •Energy Charge	 per kW " per kWh	 600.00 720.00 8.15
High Tension Power A (Contract Power: 50kW ~ 500kW)	•Basic Charge Ordinary Rate Special Rate •Energy Charge	 per kW per kWh	 725.00 870.00 8.04
High Tension Power B (Contract Power: 500kW ~ 2,000kW)	•Basic Charge Ordinary Rate Special Rate •Energy Charge Ordinary Rate Special Rate	 per kW " per kWh "	 825.00 990.00 7.70 9.25
Extra High Tension Power (Contract Power: 2,000kW or more)	•Basic Charge Ordinary Rate When supplied at 20,000V or 30,000V " 70,000V " 140,000V Special Rate When supplied at 20,000V or 30,000V " 70,000V 140,000V •Energy Charge Ordinary Rate When supplied at 20,000V or 30,000V " 70,000V " 140,000V	 per kW per kW " " per kWh 	 785.00 750.00 720.00 940.00 900.00 865.00 7.25 7.00 6.75

	Special Rate When supplied at 20,000V or 30,000V 70,000V 140,000V	per kWh " 	8.70 8.40 8.10
Temporary Power	•Flat Rate Service(in case the contract power is 5kW or less) •Meter Rate Service(in case the contract power is more than5kW) Both of Basic and Energy Charges shall be the amount equivalent to the corresponding charges under Power and Light, Low Tonsion Power, High Tension Power and Extra High Tension Power(special rate is apllied) as increased by 10%	per kW, per day	116.00
Farming Power A (Irrigation & drainage purpose)	•Basic Charge When supplied at 100V or 200V " 6,000V " 20,000V, 30,000V or 70,000V •Energy Charge When supplied at 100V or 200V " 6,000V 20,000V, 30,000V or 70,000V ※For the period other than the contract usage period, no charge is charged.	per kW " " per kWh "	250.00 250.00 240.00 4.50 4.25 4.00
Farming Power B (Heat-use for planting purpose, contract power:less than 50kW)	•Flat Rate Service(in case the contract power is 5kW or less) For the first 30 days For excess period •Meter Rate Service(in case the contract power is more than 5kW) Both of Basic and Energy Charges shall be the amount equivalent to the corresponding	per kW per kW, per day	3,618.00 103.00

	Charges under Low Tension Power as increased by 10%. For the peried other than the contract usage period, no charge is charged.		
Emergency Power A (Supplementary power for private generating customers)	•Basic Charge When used : The correspond-ind charge(special rate is applied) under High Tension Power or Extra High Tension Power shall be made to apply. When not used : The amount equivalent to 20% of the above. •Energy Charge In case of regular inspection or regular repair of the private generating facilities: The corresponding charge (special rate is applied under High Tension Power B or Extra High Tension Power) under High Tension Power or Extra High Tension Power Other cases : The amount equivalent to the above as increased by 25%		
Emergency Power B (Supplementary power source)	•Basic Charge Irrespective of the actual energy consumption, the amount equivalent to 10% of the corresponding charge under the customer's normal service is applied. •Energy Charge The amount equivalent to the corresponding charge under the customer's normal service is applied.		

Emergency Power C (Supplementary line)	•Basic Charge Irrespective of the actual energy consumption, the amount equivalent to 5% of the corresponding charge under the customer's normal service is applied. •Energy Charge The amount equivalent to the corresponding charge under the customer's normal service is applied.		
Midnight Power A (Water-heating, contract power: 0.5kW)	•Flat Rate Service	per contract	770.00
Midnight Power B (Contract power: less than 50kW)	•Basic Charge •Energy Charge	per kW per kWh	160.00 6.50
Midnight Power C (Contract power: 50kW or more)	<8 Hour Service> •Basic Charge When supplied at 6,000V " 20,000V or 30,000V •Energy Charge When supplied at 6,000V " 20,000V or 30,000V <10 Hour Service> •Basic Charge When supplied at 6,000V " 20,000V or 30,000V •Energy Charge When supplied at 6,000V " 20,000V or 30,000V	 per kW " per kWh " per kW " per kWh "	 100.00 95.00 5.95 5.70 120.00 115.00 6.25 6.00

To Be Remembered:

1 For most of the contract categories, the electric charge is the sum of the

Basaic Charge and the Energy Charge.

2 The three-block meter rate for Meter Rate Lighting B or C is equally applied to both of the existing and new customers.

3 Special increasing rate for power-use demand is applied only to the new or added demand. Customers who had a contract with the Chubu on April 30, 1974 are considered the existing customers.

Remember that such contract categories as Farming Power and Midnight Power have no special rate.

Light and Power has its special rate only in the Basic Charge regardless of the amount of contract power.

4 Power Factor Adjustment

If the power factor of the customer is higher or lower than 85%, the total basic charge is decreased or increased by 1% for each 1% by which the power factor is higher or lower than 85%.

5 Prompt Payment, Late Payment and Delinquency Interest

Prompt Payment: The payment which is made within 20 days from the following day of the meter-reading day. In this case, the prompt payment rate is applied. The rates listed so far are all prompt payment rates.

Late Payment: The payment which is made within 50 days from the following day of the meter-reading day, but after the prompt payment period. In this case, the late payment rate is applied; the late payment rate is equivalent to the prompt payment rate as increased by 5%.

Delinquency Interest: After 50 days mentioned above, the customer is charged a daily interest of 0.03%(=10.95% per annum) on his bill as a delinquency interest.

The Company may suspend the service at its own will, besides.

6 Basic Charge Reduction

For most of the contract categories, the basic charge is reduced to 50% if no energy consumption is made in the billing month.

Examples of Computation of Electric Charge

1 Meter Rate Lighting B

Contract current : 30A

Energy Consumption : 350kWh

$$\text{Electric Charge}=(¥200\times\frac{30A}{10A})+\{¥12.00\times 120kWh+¥15.40\times 80kWh+¥16.82\times(350kWh-120kWh-80kWh)\}=¥5,795$$

2 High Tension Power B

Contract power : 1,000kW (existing contract power=600kW, added contract power=400kW)

Energy consumption : 300,000kWh

Power Factor : 90% (the discount rate of the basic charge:5%)

$$\text{Electric Charge}=(¥825\times 600kW+¥990\times 400kW)\times\frac{185-90}{100}+(¥7.70\times\frac{600}{1,000}+¥9.25\times\frac{400}{1,000})\times 300,000kWh=¥3,342,450$$

APPENDIX IV: Income Redistribution: Whose Responsibility?

Improvement in the distribution of income and wealth is a long-term structural objective of Canadian government policy. This policy can be carried out by direct means, (taxation) and by indirect means, (social security systems). It includes deliberate changes either towards or away from greater equality.

One of the five economic and social goals outlined by the Economic Council of Canada is ''an equitable distribution of rising incomes''.[101]
Furthermore, the Carter Royal Commission on Taxation examining the question of the redistribution of income in 1967 considered that the allocation of taxes, given the existing transfer mechanisms and public expenditures, should provide an equitable distribution of the flow of goods and services among Canadians.

The generally accepted measure of fairness in taxation theory is *equal treatment of those equally circumstanced,* ''a principle predominantly founded on analogy with equal treatment before the law''.[102]
Although there should be a consensus in the community on this definition, differences are bound to arise from considering the relevance of any particular circumstance. Conflicts of interest are an inevitable result of any program to redistribute income. The distribution of burdens and benefits by income, size of family, age, occupation, geographic area, or any combination of such factors would cause some persons to object because their priorities were quite different. Any agency dealing with these potential sources of conflict must follow the government so closely as to become a virtual instrument of its fiscal policy.

Canadians have supported many income-maintenance programs through their historical support of governments responsible for introducing such programs. The Dominion and Provincial Governments represent all Canadians and all provincial citizens respectively. They are the only bodies capable of legislating and enforcing the degree of sacrifice or benefit an individual faces in striving for any national or provincial socio-economic objectives.

Because redistribution of wealth may conflict with other national objectives, such as economic growth or price stability, government is the only organization with the responsibility and the capability to decide between conflicting criteria. Accordingly, although Ontario Hydro supports government objectives in this area, it has not considered, and should not consider itself a policy instrument for the redistribution of wealth.

The pricing-objective of the Corporation is that the rate structure should contribute to the efficient allocation of the resources for producing electricity. Meeting this objective will result in an equitable share of relevant costs to all Ontario Hydro customer classes. However, Hydro's least-cost operation through time does not intentionally result in any movement towards or away from income equity within customer classes.

If taxation could optimally solve the problem in today's society of who should benefit from the goods produced, the problem of income distribution, then the market system would efficiently solve the problem of what kinds and quantities of all possible goods and services should be produced and how economic resources should be used to produce them. Unfortunately, as Appendix V will illustrate, society's solution to the problem of distributing income appears distressingly difficult to find.

[101]Fourth Annual Review. *The Canadian Economy from the 1960's to the 1970's*, Queen's Printer, October 1967.
[102] D. Dosser, ''Economic Analysis of Tax Harmonization'', Vol. 1, p. 20 in *Fiscal Harmonization in Common Markets.* ed. Carl S. Sharp (New York 1967), Vol. 1, p. 20.

Since the Second World War, average incomes in Canada have risen impressively. However, there is little evidence to suggest that money income has become more equally distributed. The accompanying Lorenz Curve[103] illustrates the degree of inequality of income distribution in 1951, 1961, and 1971.

It is estimated that the Government of Canada will spend 22 per cent of its total expenditures on redistribution, or public income transfers, in the 1975-1976 fiscal year. In addition, Canadian governments at all three levels make transfers in kind through health, education, and low-income housing programs.

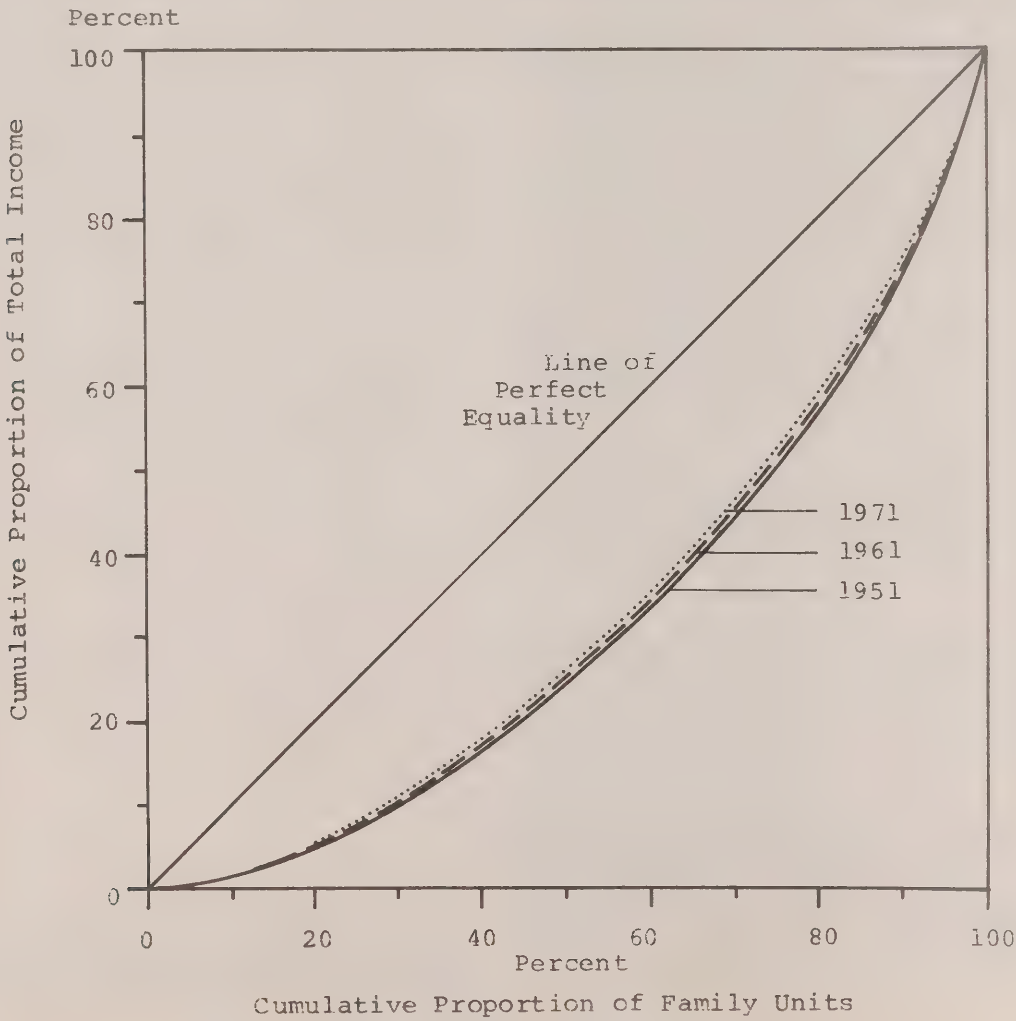
Income transfer programs attempt to attack the manifestation of poverty, that is, low incomes. Ideally, a policy designed to attack the root causes of poverty must deal with the historical, cultural, economic, social, and demographic factors which affect the distribution of income in society.

There are approximately a dozen and a half federal and provincial redistributive programs in operation in Ontario which vary in design, eligible population, and aid to the poor. One can identify four different program designs:

1. Lump Sum Payment Programs

These are payments of a specified dollar amount to all members of specified population groups. Included are Old Age Security, Family Allowances, and Youth Allowances. These programs have tended to be relatively high-cost and inefficient means of attempting to help the poor through income redistribution. All payments under these schemes are made irrespective of financial need.

[103]The greater the area enclosed by the diagonal (or equality) line and the actual Lorenz Cureve, the greater the inequality of income distribution, as measured by this method.



Dominion Government Payments In Support of Social Security Programs 1970-71 to 1975-76

	70-71	71-72	72-73	73-74	74-75	75-76
As a Percentage of Total Expenditures	14.00	15.02	20.67	19.42	18.35	22.66
As a Percentage of GNP	2.14	2.39	3.20	3.22	3.32	4.35

Ontario Spending on Social-Security Program 1970-71 to 1975-76

	70-71	71-72	72-73	73-74	74-75	75-76
As a Percentage of Total Budgetary Expenditures	9.42	9.64	10.13	12.41	14.93	15.36
As a Percentage of GPP	1.76	1.90	1.92	2.35	2.65	3.01

Source: The Report of the Special Program Review, p. 169-170.

2. Social Insurance Programs

The benefits of these relate to prior contributions; examples are the Canada Pension Plan, Unemployment Insurance, Veterans' Pensions, and Workmen's Compensation. The direct relationship between benefits and past earnings reflects the fact that the social insurance programs are largely designed to protect against partial or total loss of income on account of age, unemployment, or injury.

While the contribution of these programs to alleviating poverty is an important secondary goal, they are not especially effective, owing to the relation of benefits to previous earnings; for example, a family that is poor because earnings are low will remain poor after receiving low unemployment insurance benefits.

3. Income Related Programs

Examples of current income related programs are the Guaranteed Income Supplement designed to aid the aged poor, General Welfare Assistance, and Ontario's Tax Credit. Under these schemes transfers or rebates are inversely related to an individual's income. These programs appear to be the most efficient, and thus least costly, method of isolating and helping those in actual need.

4. Social Assistance Programs

Generally, under these federal-provincial cost-sharing programs, the provinces define the conditions under which an individual or family may be eligible to receive payments. Once eligible, the level of payment is based on a family's needs, determined by a budget. The programs are the Canada Assistance Plan, Aid to the Blind, Aid to the Disabled, Unemployment Assistance, and Native and Inuit Assistance.

Unlike the income-related programs in which benefits are based on annual income and age, social assistance schemes are based on an estimate of needs and resources at a particular point in time. However, if the family or individual has an income or resources of its own, some, or often all, of these will be subtracted from the monthly payment.

The main problems of Canada's present welfare system can be briefly summarized. This summary is a synthesis of the concerns of economists, sociologists, and others working in the area. It should not be taken as representing Ontario Hydro's official viewpoint on the subject.

First, current programs do little to aid the working poor. Working poor means those families headed by an employed person whose earnings are very low in relation to the family's needs. If

the family has dependent children, they will receive specified amounts from Family Allowance and/or Youth Allowance. However, the working poor are unlikely to be eligible for any social assistance (SA) programs. There may be a perverse effect here, since qualification for an SA program may mean that an increase in the family's resources (including earnings) results in a decrease in assistance, possibly damaging the incentive to work. The implicit discouragement in the programs in attempting to improve one's standard of living through employment fosters dependence on the program and apathy toward work. It is impossible to measure the psychic and social costs of an inefficient redistributive program.

A second general problem with current programs is their inability to restrict their aid to the poor. Government estimates[104] suggest that important programs such as Family Allowances, Youth Allowances, Canada Pension Plan and Unemployment Insurance pay between 10 and 30 per cent of their benefits to those who would be poor without transfer payments. Most other programs pay approximately 70 per cent to these poor people, the exeption being the Guaranteed Income Supplement, which pays them 100 per cent of its benefits.

The final general criticism of the present system is the multiplicity of programs and their soaring costs and "suspect" efficiency, which are putting a tremendous fiscal burden on the public. Any proposal which would streamline the administrative and operative difficulties of current programs and procedures would release money for activities generating employment and income. Spending and beneficiaries for the chief social-security programs in Ontario are summarized in the accompanying table.

[104]Department of Health and Welfare, *Income Security for Canadians*, (Ottawa, 1970).

TRENDS IN EXPENDITURE AND NUMBER OF BENEFICIARIES OF MAJOR SOCIAL SECURITY PROGRAMS IN ONTARIO

	FISCAL YEAR				
	1959-1960	1965-1966	1970-1971	1972-1973	1974-1975
1. Social Assistance (Family Benefits and General Welfare Assistance)					
· Transfers ($ millions)	52.9	100.8	231.3	275.5	246
· Number of Recipients (average monthly caseload)	69,933	90,120	139,833	157,771	N/A
2. Old Age Security					
· Transfers ($ millions)	208.6	337.2	603.0	653.4	961.4
· Number of Recipients (thousands)	300	400	630	670	703
3. Guaranteed Income Supplement					
· Transfers ($ millions)	—	—	78.5	228.0	250.3
· Number of Recipients (thousands)	—	—	270	330	341
4. Family Allowances					
· Transfers ($ millions)	156.7	182.4	191.4	190.3	633.6
· Number of Children (thousands)	900	2,340	2,400	2,400	2,500
5. Day Nurseries					
· Expenditure ($ millions)	0.2	0.4	3.3	14.5	N/A
Number of Places	9,865	14,[illegible]60	27,150	35,565	N/A
6. Unemployment Insurance					
· Total Benefits ($ millions)	125.4	81.9	253.7	637.4	676.1
Claimants (monthly average)	146,250	89,[illegible]50	194,500	263,000	268,300
7. Gains					
Transfers ($ millions)	—	—	—	—	74.1
Number of Recipients	—	—	—	—	36,500

SOURCES:

Social Assistance, Day Nurseries, Gains

Department of Public Welfare, **29th Annual Report**, 1959-1960. **35th Annual Report**, 1965-1966.

Department of Social and Family Services, **40th Annual Report**, 1970-1971.

Ministry of Community and Social Services, **Statistical Supplement, 42nd Annual Report**, 1972-1973, **Quarterly Statistical Bulletin**, March 1975.

NOTE: The expenditure figures include federal, provincial, and municipal participation.

Family Allowances, Old age Security, Guaranteed Income Supplement

Canada Year Book, Queen's Printer, Ottawa, 1961, 1967, 1972, 1974. 1974-1975 figures were provided by Health and Welfare Canada.

Unemployment Insurance

Statistics Canada, Statistical Report on the Operation of the Unemployment Insurance Act, Information Canada, Ottawa, Catalogue 73-001.

APPENDIX VI: Negative Income Taxation

This appendix will discuss what many economists consider to be an efficient method of redistributing income. Any analysis or conclusions arising from this section is in no way intended to reflect Ontario Hydro's policy or views in this area. The appendix is included for purposes of information only.

> *The social welfare structure so laboriously and painstakingly created in Canada over the past forty years has clearly outlived its usefulness. The social scientists who have studied it, the bureaucrats who have administered it, are of one mind that in today's swiftly changing world, the welfare system is a hopeless failure. The matter is not even controversial; everybody's against it. But what is to take its place?*[105]

> *The (Federal) Cabinet's committee on social policy agreed at a July meeting that statistical evidence shows very little change has occurred in the distribution of income among Canadians over the past 20 years.*[106]

> *Let's get on with the task of determining how we can revise our current system so that public money now being spent on income security goes to those in need, doesn't penalize people willing and able to work, and rewards those who do work by helping them meet their basic human requirements in those instances where their earnings aren't enough.*[107]

The apparent lack of success of many past and present welfare measures has resulted in new proposals, in both Canada and the United States, to use the income-tax system to transfer income to low-income households. One of the promising and efficient economic proposals is 'negative income taxation', the theory of which was originally developed by Milton Friedman.

Negative income taxation would directly redistribute household income to low-income families, and would place a floor under family income.

The accompanying graph illustrates a progressive tax system which taxes incomes greater than (to the right of) A. For a family with total income less than A (left of A), a marginally progressive negative tax or credit is shown. If a household's income were 0, then they would be eligible for the maximum credit allowable (OC), the minimum income necessary to support a specified satisfactory standard of living. To avoid creating a disincentive for work, any proposal of this kind must allow the family to retain at least a decreasing portion of any income earned. If, for example, a family earned income OD, then they would be eligible for a tax credit of DE. OD plus DE must be greater than OC, so as not to provide a disincentive to work.

This method, which provides a guaranteed income to all households and individuals in need, allows them to choose their own pattern of spending. Making the poor capable of voting with dollars will not only increase individual satisfaction but will allow them to function better in the market system, and in turn, increase demands in the economy. Because the negative income-tax, unlike any program of stamps or lifeline-rates, is directly related to the market-system, without other intermediary, the built-in pressures for the recipient to channel his expenditures into restrictive categories does not exist.

The advantages of negative income-taxation as a tool for redistribution are the following:[108]

1. The negative income tax scheme is more impartial than such devices as life-line rates, energy stamps, allocating resources to raise the income of those whose earning potential is very low. Futhermore, marginal rates of substitution between various commodities is not distorted by this means.

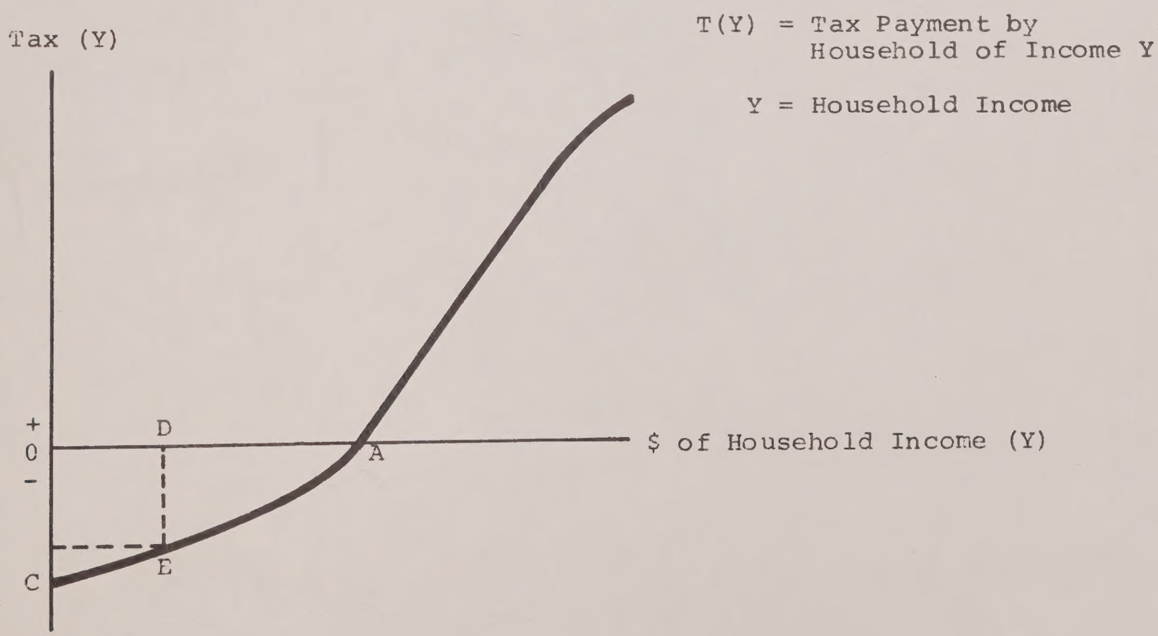
---

[105]Special Senate Committee on Poverty, *Poverty in Canada*, (Ottawa, 1971), p. vii.

[106]*Toronto Daily Star*, November 7, 1975.

[107]Editorial, *Toronto Daily Star*, February 9, 1976.

[108] C. Green, "Transfer Mechanisms, Redistribution and Canada's Proposed Tax Reform", *Conference Report*, Canadian Tax Foundation, November 1967.



2. This instrument would provide and confine income transfers to households with a definite requirement for economic assistance.

3. Because payments would be based solely on household income and size, the system should achieve a degree of horizontal equity in the treatment of low-income households not possible under current income-transfer programs.

4. The proposal may stimulate incentives to work among populations at present subject to 'tax rates' of 100 per cent in public assistance programs.

An important problem facing all schemes of redistribution is how to identify the poor. The official count is generally based on annual income. It is conceivable that in the long run, the absolute nature of this measure could result in all citizens finding themselves above a set poverty-line without any equalization in the relative distribution of income. Assuming that this will not occur, income redistribution remains an accepted method of increasing incomes to fight poverty.

However, low income may not be truly indicative of poverty; for example, the low income of the medical or law student is a transitory experience in the life of an individual with attractive earnings expected in the future. Similarly, the low income of a senior citizen may not reveal that he is gradually consuming his accumulated assets.

As mentioned previously, this problem of the identification or measurement of poverty is inherent in all social programs helping the financially disadvantaged. Once the relevant group has been identified, the scheme likely to redistribute income most efficiently is negative income taxation.